出國報告（出國類別：開會）

第四屆台英再生能源圓桌會議與英國再生能源參訪出國報告

服務機關：台灣電力公司

姓名職稱：胡克鴻主管

派赴國家：英國

出國期間：98 年 10 月 4 日至 10 月 10 日

報告日期：98 年 12 月 1 日

出國報告審核表

出國報告名稱：第四屆台英再生能源圓桌會議與英國再生能源參訪出國報告		
出國人姓名(2人以上，以1人爲代表)	職稱	服務單位
胡克鴻	主管	台灣電力公司電源開發處
出國期間：98年10月4日至98年10月10日		報告繳交日期：98年12月1日

出國計畫主辦機關審核意見	■1.依限繳交出國報告 ■2.格式完整（本文必須具備「目地」、「過程」、「心得」、「建議事項」） ■3.內容充實完備. ■4.建議具參考價值 □5.送本機關參考或研辦 □6.送上級機關參考 □7.退回補正，原因：□ 不符原核定出國計畫 □ 以外文撰寫或僅以所蒐集外文資料爲內容以 □ 內容空洞簡略 □ 電子檔案未依格式辦理 □ 未於資訊網登錄提要資料及傳送出國報告電子檔 □8.本報告除上傳至出國報告資訊網外，將採行之公開發表： □辦理本機關出國報告座談會（說明會），與同人進行知識分享。 □於本機關業務會報提出報告 □9.其他處理意見及方式：
層轉機關審核意見	□1.同意主辦機關審核意見□全部 □部分_____（填寫審核意見編號） □2.退回補正，原因：_____ □3.其他處理意見：

說明：

一、出國計畫主辦機關即層轉機關時，不需填寫「層轉機關審核意見」。

二、各機關可依需要自行增列審核項目內容，出國報告審核完畢本表請自行保存。

三、審核作業應於報告提出後二個月內完成。

報告人：胡克鴻 98.12.1

單位主管：王曉正 98.12.2

主管處主管：何建輝 98.12.4

1

總經理：

副總經理：黃憲章 98.12.7

行政院及所屬各機關出國報告提要

出國報告名稱：第四屆台英再生能源圓桌會議與英國再生能源參訪出國報告

頁數 115 含附件：■是□否

出國計畫主辦機關/聯絡人/電話　台灣電力公司/陳德隆/(02)2366-7685

出國人員姓名/服務機關/單位/職稱/電話

胡克鴻/台灣電力公司/電源開發處/主管/(02)2366-7545

出國類別：□1 考察□2 進修□3 研究□4 實習■5 其他(開會)

出國期間： 98 年 10 月 4 日至 10 月 10 日　出國地區： 英國

報告日期： 98 年 12 月 1 日

分類號/目

關鍵詞：再生能源(Renewable Energy)、風能(Wind Energy)、海洋能(Ocean Energy)、離岸風力發電(Offshore Wind Power)

內容摘要：(二百至三百字)

一、英國再生能源技術先進，尤其是離岸風電、波浪發電及潮流發電等，已有許多發展經驗值得國內學習。台英雙方自 95 年開始推動再生能源領域技術交流，已舉辦三屆「台英再生能源交流合作圓桌會議」，以及多場再生能源國際研討會，並派員輪流互訪，成果豐碩。

二、為持續台英雙邊交流成果，本（98）年度繼續舉辦「第四屆台英再生

能源交流合作圓桌會議」，於英國進行，邀集相關廠商、專家進行再生能源議題討論，以增加技術交流與互惠合作的機會。本次圓桌會議我方由能源局葉惠青局長領隊，邀請國內相關單位組團參加會議。

三、此外，本次行程亦順道安排參訪風力發電、海洋能發電及燃料電池等業界相關公司，以瞭解英國領先之發展技術現況，並參加 Energy Solutions Expo 2009 展覽，了解能源管理與節能相關產業，該展覽為尋求國際技術交流的極佳平台

本文電子檔已傳至出國報告資訊網（http：//report.gsn.gov.tw）

目　錄

一、出國緣起及目的

英國再生能源技術先進，尤其是離岸風電、波浪發電及潮流發電等，已有許多發展經驗值得國內學習。台英雙方自 95 年開始推動再生能源領域技術交流，已舉辦三屆「台英再生能源交流合作圓桌會議」，以及多場再生能源國際研討會，並派員輪流互訪，成果豐碩。

為持續台英雙邊交流成果，本（98）年度繼續舉辦「第四屆台英再生能源交流合作圓桌會議」，本次圓桌會議擬訂三項討論議題：1.推動風電與產業發展、2.海洋能發展、3.燃料電池，邀集相關廠商、專家進行再生能源議題討論，以增加技術交流與互惠合作的機會。

我方由能源局葉惠青局長領隊，邀請國內工研院、台灣造船、台電、東元電機、中興電工、美菲德公司、成功大學等相關單位組團參加會議並順道安排參訪。本次行程規劃參訪風力發電、海洋能發電及燃料電池等業界相關公司，以瞭解英國領先之發展技術現況，並參加 Energy Solutions Expo 2009 展覽。本公司指派職代表參團，以了解英國再生能源發展情形，作為本公司推動之參考。

二、出國行程及人員

本次出國主要任務係舉辦「第四屆台英再生能源圓桌會議」，進行再生能源相關議題討論，以增加台英雙方瞭解及未來合作機會。參訪期間安排拜會政府單位，如英國能源暨氣候變遷部，以及參訪英國再生能源相關廠商及研究單位，包括研發燃料電池技術之Intelligent Energy Ltd.、CATAL International Ltd.等公司，新及再生能源研究中心（New and Renewable Energy Centre），以及參加海洋能技術活動 PRIMaRE。此外，本次亦安排參觀展覽 Energy Solutions Expo 2009，以瞭解能源管理與節能相關產業。：

(一) 出國行程

本次我方代表團於 98 年 10 月 4 日出發，當日晚間抵英，並於次日展開英國參訪行程，訂於 98 年 10 月 8 日舉辦「第 4 屆台英再生能源圓桌會議」，訪英行程至 10 月 9 日結束返國，10 月 10 日抵台。行程規劃重點如下表所示：

日期	參訪公司 / 會議	行程重點摘述
10/4	去程	
10/5	• Intelligent Energy Ltd.	燃料電池研發公司
	• Romax Technology Limited	風力機齒輪箱合作公司
	• CATAL International Ltd.	燃料電池研發公司
10/6	• New and Renewable Energy Centre	參訪新及再生能源研究中心，瞭解風機葉片測試、海洋能實驗及太陽光電研發中心
	• Northumberland College	離岸風力機營運訓練

10/7	A 團：PRIMaRE 海洋能活動—SEA opportunities for enterprise	瞭解英國海洋能領域的技術研究與 Wave Hub 的最新相關開發狀況
	B 團： Centre for Process Innovation Ltd.	在燃料電池技術方面討論台英合作的模式與機會
10/8	• Energy Solutions Expo 2009	參觀展覽以瞭解能源管理與節能相關產業
	• 第四屆台英再生能源圓桌會議	舉辦第四屆台英再生能源圓桌會議，台英雙方進行議題討論
10/9	Department of Energy and Climate Change	拜會英國能源暨氣候變遷部，瞭解英國政府於能源政策與減緩氣候變遷政策的制定及成效
10/10	回程	

(二) 我方代表團成員

代表團將由葉惠青局長擔任團長及會議共同主席，產官學研各界參加團員有 17 位，名單如下。我國駐英國台北代表處經濟組陳榮驤組長，及廖浩志秘書亦於英國當地提供協助。此外，英國貿易文化辦事處尹德惠組長亦全程陪同，協助與英方之拜會單位聯繫及安排交通住宿。

1. 葉惠青 / 能源局 局長
2. 陳炯曉 / 能源局 綜合能源業務科 科長
3. 童遷祥 / 工研院機械所 副所長
4. 曹芳海 / 工研院能環所 組長
5. 吳啟斌 / 中興電工機械股份有限公司 處長
6. 徐志彬 / 美菲德有限公司 總經理

7. 顏志偉 / 工研院能環所 組長
8. 顏厥正 / 工研院能環所 研究員
9. 高瑞棋 / 國立成功大學水工試驗所 副所長
10. 黃正亮 / 國立成功大學海洋能科技研究中心 特聘教授
11. 陳建富 / 國立成功大學電機工程學系 系主任
12. 李燕強 / 台灣國際造船股份有限公司 課長
13. 林福堂 / 台灣國際造船股份有限公司 副理
14. 胡克鴻 / 台灣電力公司 電源開發處 課長
15. 馮英芳 / 東元電機股份有限公司 經理
16. 胡斯遠 / 工研院能環所 工程師
17. 李欣哲 / 工研院能環所 經理
18. 鄭孟寧 / 工研院能環所 副研究員

三、第四屆台英再生能源交流合作圓桌會議紀要

■ **時間**：10 月 8 日（星期四）13：40～17：30

■ **台方與會人員**

我方代表團全體 17 位成員，及駐英國台北代表處經濟組陳榮驤組長與廖浩志秘書。

■ **英方與會人員**

1. Richard Brooks / DECC / Head of Business Development Renewables Deployment Team
2. John Buckley / UKTI / Renewables Adviser
3. Peter Poon / Romax / CEO
4. Xiaobing Hu / Romax / Sales Director
5. Robert Rawlinson-Smith / Garrad Hassan & Partners / Marine Renewables Group Leader
6. Allan MacAskill / Sea Energy Renewables / Business Development Director
7. Joseph Hussey / Wind Prospect
8. Robert Speht / Mott MacDonald / Wind Energy Manager
9. Makhlouf Benatmane / Converteam / Director & Market Segment Leader
10. Gareth Davies / Aquatera / Managing Director
11. Ian Hutchison / Aquatera / Consultant
12. Michael Starling / BMT Fleet Technology / Principal Consultant
13. David Hunt / Ocean Navitas / Managing Director
14. James McCague / Ocean Navitas / Technical Director
15. Alistair Knight / Ocean Navitas / Business Development Manager
16. Fraser Johnson / Orecon / Technical Director

17. Colin Harper / Qinetic / Key Account Manager
18. Jonathan Butler / Fuel Cell Today / Analyst Asia
19. Dennis Hayter / Intelligent Energy / Business Developemnt Director
20. Martin Green / Johnson Matthey / Strategic Development Director
21. Jonathan Kearney / CPI
22. James Lewis / Bac2 / Chairman
23. Stephen Barlow / CMR Fuel Cells
24. Robert Lane / CMS Cameron McKenna / Partner
25. Matthew Wood / UKTI
26. 尹德惠 Annie Yi / British Trade & Cultural Office (BTCO) / Senior Commercial Officer, Infrastructure Projects /

■ 議題一：推動風電與產業發展

1. 台方引言代表：童遷祥副所長 / 工研院機械所
2. 台方引言簡報：Opportunity in Offshore Wind Energy

(1)台灣政策鼓勵離岸風力發電，包括：2007 年的 SRB 產業科技策略會議，規劃風力發電為國內再生能源發展最重要的項目之一；2009 年全國能源會議，風力發電為選定重點潛力產業之一，政府將協助產業研發；2009 年 6 月「再生能源發展條例」通過，將制定再生能源電價之補貼方案，有助業者投入研發。

(2)台灣再生能源國家目標，為 2025 年時再生能源裝置容量佔比達 15%。

(3)台灣風力資源豐富，估計 4800 MW 以上，含陸域 1600 MW 及海域 3200 MW。其中，最佳風況在台北縣往南至彰化縣，陸域滿發時數為 2800～3200 小時，還有離島澎湖陸

域滿發時數為 3300～3900 小時。

(4)台灣風力機設置現況，目前設置風力發電場 17 處，風力機 200 座，完工裝置容量 380 MW，年發電量為 10 億度(1,000 GWh)，可提供家戶用電有 25 萬戶。

(5)台灣風力發電產業推動現況，台灣已具備完整風力機產業供應鏈雛型，國內業者已投入自主性系統技術開發。產業鏈包括原材料、零組件、系統、風場營造商、風場營運商等各家公司。

3. 英方引言代表：Joseph Hussey / Wind Prospect

4. 英方引言簡報：UK Wind Energy

(1)英國陸域風力，擁有歐洲最好的風力資源，第一座風力機建造於 1991 年，現在營運中的風場有 240 處，裝置容量為 3,233 MW；目前正在建造的為 29 案，裝置容量為 812 MW；而已被同意設置的有 158 個計畫，容量為 3,279 MW；還在開發階段的案件有 264 件，7,386 MW；目標到 2020 年至少達 14 GW。

(2)英國離岸風力，世界離岸風力的領導者，目前營運中的風場有 8 處，裝置容量為 598 MW；正在建造的有 6 案，1,246 MW；已被同意設置有 9 案，3,613 MW；還在開發階段有 5 案，2,639 MW；目標到 2020 年更進一步達 25 GW。

(3)制定政策與方案，全球離岸風電最好的誘因。Licensing Rounds：Round 1－2001 年(1GW)，Round 2－2003 年(7.2 GW)，Round 3－2009 年(25 GW)。Strategic Environmental Assessment (SEA) 考慮離岸風力達 33 GW 的環境影響，新的特許制度對離岸電力傳送較便宜也更適時的連接。

圖 13、雙方代表進行風力發電引言簡報

■ **議題二：海洋能發展**

1. 台方引言代表：顏志偉組長 / 工研院能環所 資源技術組
2. 台方引言簡報：Ocean Wave and Current Energy Development in Taiwan

(1)台灣發展海洋能源的潛能，波浪能為 10～15 kW/m，潮流發電 0.78～1.05 m/s (澎湖大橋區域)，洋流發電(黑潮) 1.05～1.60 m/s (東部海岸)。

(2)台灣潮流發電發展現況，國立成功大學水工試驗所已研發潮流發電的裝置，也有測試設備、模型及平台。

(3)台灣波浪發電發展現況，工業技術研究院利用波浪能源模擬模型去計算波浪潛能，也研發波浪發電裝置動力分析，透過流體力學分析，發現最佳與最差的反應條件，作為效率分析及結構力量分析。

(4)未來台英合作波浪發電的發展策略，整體目標是國內海域數十瓩級波浪發電應用示範運轉。

3. 英方引言代表：Robert Rawlinson-Smith / Garrad Hassan / Marine Renewables Group Leader

(英方無引言簡報)

圖 14、雙方代表進行海洋能議題引言

■ **議題三：燃料電池**

1. 台方引言代表：曹芳海組長 / 工研院能環所 新能源技術組
2. 台方引言簡報：PEMFC Demonstration/Validation & Technology Development in Taiwan

(1)全球燃料電池趨勢與情況。

(2)台灣策略目標。

(3)台灣發展現況與趨勢，快速成長與競爭的國內產業，集中發展分散式及定置型系統。氫能與燃料電池已存有成熟的產業供應鏈，並具備在小型產業與消費者產品的優秀生產經驗。

(4)質子交換膜燃料電池(PEMFC) 電熱共生(CHP)系統成本分析，並介紹系統結構的耐久性與成本選擇。

(5)台英合作建議提案：

- 雙方業者或學研界合作，分別於台灣與英國進行燃料電池系統示範驗證與實證；
- 雙方業者或學研界合作開發適用於歐盟市場之利基應用產品 (PEMFC 產品)；
- 雙方學研界及業者共同進行耐久或次世代關鍵組件技術研發 (在 FP7 架構下)；
- 台灣引進英國關鍵技術。

3. 英方引言代表：Jonathan Butler / Fuel Cell Today / Senior market Analyst - Asia
4. 英方引言簡報：The State of the Global Fuel Cell Industry and UK Expertise

(1)全球燃料電池產業及趨勢介紹。

(2)英國燃料電池與氫能技術，英國透過完整的供應鏈，處於產業及商業的領導地位，也有與產業連結的許多研發能量，及廣大的合作參與者，包括有零組件、系統製造商、

關鍵投資者如金融業和市場技術顧問。

(3)英國燃料電池相關政策。

(4)英國研發燃料電池技術與產品的學校與公司。

圖 15、雙方代表進行燃料電池引言簡報

■ 會議結論

Conclusion of the 4th Round Table Meeting

In today's discussion, several important conclusions have been made. Here, I want to summarise some of them.

About offshore wind, further seminars should be organised.

We would like to invite UK experts to visit Taiwan to discuss and exchange expertise. We would like to request UK's assistance to initiate training programme for workforce and for design and planning of offshore wind farms. Possibility of joint activity for China's market is an area which we can explore for mutual benefits. Most importantly, concrete development projects to cooperate with UK companies are expected with Taiwan's new tariff rates for renewable electricity.

As to marine energy, fostering a manufacture industry is one of our targets for developing ocean energy. This is an area which both Taiwan and UK can cooperate to seek lower cost and better performance. We agree to set up a marine energy promotion group to foster concrete collaboration on both commercial and academic bases. Furthermore, Taiwan will work out a comparison on mutual strength and weakness to explore further areas of cooperation. Taiwan has recently established a new marine energy research centre and testing facility, I cordially welcome your visit.

About fuel cells, both UK and Taiwan agree to seek further cooperation in this important emerging area. We agree that Taiwan as the preferred manufacturer of fuel cells for UK companies is a common interest. We agree that code and standard are essential to the commercial success. Further endeavours will be seek in this aspect. Joint proposals by UK and Taiwan under JTI or FP7 framework could be considered.

在雙方的討論中，已經達成了幾項重要的結論，總結如下：

1. 關於離岸風力，進一步的專家討論會應該更有組織，我們想要邀請英國專家訪問台灣，以進行討論及技術交流，亦希望英國協助為風電從業人員還有離岸風場的設計規劃來開設訓練課程。針對中國市場潛在的聯合行動是我們能探討共同互惠的範圍。最重要的是與英國公司合作的具體發展計畫期

待台灣新的再生能源電能費率。

2. 關於海洋能源，扶植製造產業是我們發展海洋能的目標之一，這是台灣與英國能合作尋求較低成本及更好成果的領域。我們同意在商業和學術基礎上成立一個海洋能促進小組以促成具體合作，而且台灣將比較相互的優劣勢，以開發更進一步的合作領域。台灣最近成立新的海洋能研究中心及測試設備，誠摯地歡迎你們來訪。

3. 關於燃料電池，台英雙方皆同意在這個重要且新興的領域尋求更進一步的合作。對英國公司而言，台灣作為燃料電池的優先製造商將對雙方有共同利益。此外，法規與標準對商業成功是不可或缺的，將在這方面尋求更進一步的努力，亦可考慮英國和台灣在 JTI 或 FP7 的框架下進行共同研發計畫的提案。

圖 16、第四屆台英再生能源交流合作圓桌會議

四、其他參訪行程紀要

(一)參訪 Intelligent Energy Ltd.

- 時間：10 月 5 日（星期一）上午 10：00～11：30
- 英方會談人員/職稱/單位：

1. Dr. Jon Moore / Director of Communications / Intelligent Energy
2. Dr. Henri Winand / Chief Executive / Intelligent Energy
3. Mr. John Buckley / Global Value Chain Specialist / UK Trade & Investment (UKTI)

- 參訪紀要：

訪英行程從參訪位於 Loughborough 的 Intelligent Energy 公司展開。Intelligent Energy 為發展潔淨動力系統的公司，具備燃料電池及氫能發電技術，並生產各方面應用的發電系統，例如航空、防禦、交通運輸、能源及分散式電力系統等。Intelligent Energy 專利的燃料電池及氫能發電技術平台的發展，為英國政府及工業所面臨能源供應及困難環境的挑戰，提供了解決之道，並有建築大廈預定的發電系統設備製造商與其全球廣大的市場，也擁有超過 100 名的員工在英國總部、美國及日本等地。

Intelligent Energy 於 2001 年開始商業營運，但早在 1980 年代晚期就已有研究燃料電池技術，是具有潔淨能源未來展望的動力系統公司。Intelligent Energy 專利的質子交換膜(PEM)燃料電池表現出高電力密度，使得製造更經濟化。其獨特的燃料電池動力系統排除傳統燃料電池設計所需要的許多零件，而導向低成本、更緊密的系統。此外，透過公司伙伴模式，Intelligent Energy 的世界級團隊帶來燃料電池、氫能發電、低碳技術等應用在四大全球目標市場：航空與防禦，分散式電力與攜帶式電力，石油與天然氣，以及起動電力。

圖 1、參訪 Intelligent Energy Ltd.並聽取簡報

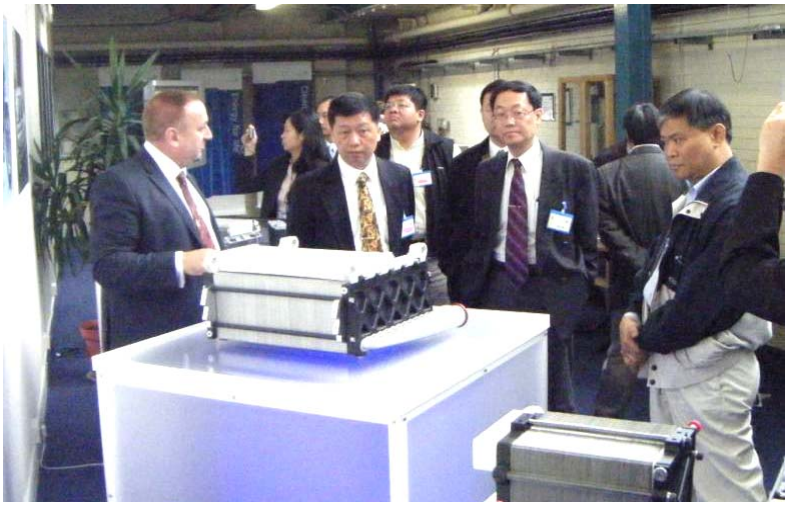


圖 2、參觀 Intelligent 燃料電池產品及實驗室

圖 3、Intelligent 研發之燃料電池機車展示

(二)參訪 Romax Technology Limited

- 時間：10 月 5 日（星期一）上午 12：30～14：00
- 英方會談人員/職稱/單位：

1. Dr. S.Y. Poon / Managing Director / Romax Technology
2. Dr. Xiaobing Hu / Director of Business Development / Romax
3. Ms. Suzi McCracken / Business Development Executive / Romax Technology
4. Mr. John Buckley / Global Value Chain Specialist / UKTI

■ 參訪紀要：

Romax Technology 公司的董事長於去年度來台訪問，並參加上屆的台英再生能源圓桌會議及研討會，與國內廠商有技術交流的契機，進而與工研院機械所、東元電機、台朔重工等公司積極展開接洽與討論，於今年度分別完成簽約，合作開發風力機製造技術，主要以風力機傳動系統設計技術、傳動測試平台設計與分析為合作項目。故本次行程特別安排至該公司位於 Nottingham 之總部進行參訪，董事長 Dr. Poon 親自接待本代表團，並介紹公司主要業務。

創建於 1989 年的 Romax Technology 有限公司，為變速箱、傳動系統和軸承，提供技術諮詢、設計及軟體產品。在汽車、航空航太、風力發電和鐵路工業等方面，與世界頂尖的工程公司、OEM、元件供應商及高科技公司等廣泛合作，並致力運用在傳動系統和軸承領域的知識，提供迅速開發產品且有效的解決方案。藉由其專家工程團隊和概念先進的軟體，將實際設計經驗和高級分析技術完美的結合。

擁有優秀的傳動系統設計與分析能力，Romax 的工程物件傳動系統快速建模方法，目前已成為業界的標準，其套裝軟體包括 RomaxDesigner、RomaxDurability、RomaxDynamics 和 RomaxNVH，實現在單一環境下滿足用戶所有需求，如：傳動系統建模、仿真和分析。還有 CAE 軟體為變速箱設計、分析和虛擬測試提供了一套完整的方案。Romax 工程團隊提供傳動系統設計和分析方面的全方位服務，包括：NVH 研究、變速箱設計、設計概念衍生、設計評論和產品詳細設計。還可透過在德國、日

本、美國、韓國、中國、英國和印度的分公司或辦事處，為客戶的工程計畫提供當地的協助。此外，亦提供諮詢服務，如標定服務、技術支援套裝、NVH 與動力學分析、CAE 分析、變速箱的設計與開發等。

圖 4、參訪 Romax Technology Limited

(三)參訪 CATAL International Ltd.

- 時間：10 月 5 日（星期一）15：00～16：30
- 英方會談人員/職稱：Mr. Andrew Holt / Director
- 參訪紀要：

CATAL 成立於一九八八年，致力於提供催化過程產業專業的研發、製造與科技服務。服務項目包括異質催化劑的研發與製造，及催化過程設備的設計建置，而主要的專案包涵化工、製藥業、汽車業、石化業、核能業及環保產業。其研發及製造能力可提供給客戶高成本效益的解決方案，這都源自於 CATAL 在催化過程及化學工業方面研發、製造及商業營運累積的實務經驗。

圖 5、CATAL International Ltd.簡報並說明研發產品

(四)參訪 New and Renewable Energy Centre (NaREC)

■ 時間：10 月 6 日（星期二）10：00～13：00

■ 英方會談人員/職稱/單位：

1. Ms. Lisa Dodds / Business Development Manager - Wind and Marine / NaREC
2. Dr. Jamie Grimwade / Technology Specialist - Marine / NaREC
3. Mr. Steve Abbott / NaREC
4. Mr. John Buswell / Project Manager / Clipper Windpower Marine, Ltd.
5. Dr. Emma Toulson / Project Manager Offshore Renewables / East of England Development Agency

■ 參訪紀要：

新及再生能源中心 NaREC 是英國政府設立的研究機構，位於 Blyth Harbour，距離新堡 Newcastle 約半小時車程。其設立目的為加速新能源技術之研發，促進永續能源經濟的成長，並致力於發展再生能源電網整合及低碳發電技術，應用於風力、波浪發電、潮汐發電、太陽光電及熱能等。同時，也研擬相關政策以促進英國再生能源及新能源技術提升與產業發展。

NaREC 與全球的跨國績優公司、中小型企業、各大學研究機構合作，將電能與熱能相關科技商業化，並應用在電力網或大型能源分配系統。該中心主要營運的範圍在陸上及離岸風力、波浪與潮汐、電力網及能源配置系統，並提供產業和工程顧問服務、測試設備、研發以及商業支援。透過私人合約及投資者資助研發，NaREC 目前進行全國性及區域性的多項計畫，來提供客戶供應鏈方面的服務。其專業能力及有彈性的測試設備，亦可應用於其他產業，如汽車、航空、通訊及海洋相關業者，來處理陸域或海域在電力、工程及環境方面所面臨的挑戰。

風力發電部分，英國積極推動離岸風力發電，由於產業無力負擔離岸風機失敗的巨大成本，因此風力機在設置前必須經過完整的有效性測試，以確保大型風機葉片之安全及可靠性。NaREC 擁有先進的葉片測試設施、內部技術和原型開發能力，可在一個獨立且保密的環境，為製造商提供驗證新設計和提高可靠程度的機會。

英國海洋能源相當豐富，亦為全球海洋能技術先進國家，加上政府積極挹注經費與政策鼓勵，在波浪發電(Wave Energy)及潮流發電技術(Tidal Current Energy) 的研發更是居世界領先之地位。NaREC 擁有設計工程與原型測試的能力，正協助波浪及潮流開發商將創新的設計概念朝向商品化；亦有工程諮詢服務，提供概念評估和技術專業予投資者及海洋開發者，可結合市場情報、工程設計及技術評估。同時 NaREC 也建立策略聯盟，與學術界、產業界、非政府、政府及貿易組織合作，藉由最好的技術與經驗，大大增加海洋能發電或供應鏈專案的成功機會。

NaREC 之太陽光電研究中心(PV Technology Centre)是英國唯一且獨立的結晶矽太陽能電池商業研發組織，有完善之太陽能電池製程及測試設施。該中心有國際知名的研究團隊，更保有大面積的單晶矽與多晶矽太陽能電池轉換效率之世界紀錄，亦有大規模生產太陽能電池的經驗，包括 Laser Grooved Buried Contact (LGBC)以及 Screen Printed Cells。

圖 6、NaREC 簡報並進行技術討論

(四)參訪 Northumberland College

- 時間：10 月 6 日（星期二）14：00～16：00
- 英方會談人員/職稱：Mr. Ian Fisher / Sustainable Energy Manager
- 參訪紀要：

Northumberland 大學最初的風力訓練課程，是由 TNEI (Independent energy consultancy, new energy technologies) 與 NaREC、NREG (Northumberland Renewable Energy Group)、LSC (Learning and Skills Council)於 2004 年底開始合作，2005 年 2 月協助發展風力及生質能引導訓練模式。風力引導課程(Wind Pilot Programme)一開始以大型陸域風場的技術人員訓練為目的，吸引了約 20 個組織參加，也得到大量有建設性的批評與回饋，大多數要求更多實際的活動及練習，回饋亦有來自產業和允許進入歐盟計畫的德國教育學者等關鍵參與者。

Northumberland 大學的技術人員訓練之發展過程，是先訪問德國 Bremen 大學，以瞭解他們如何訓練風力技術人員，且參與最初的 Power Project，然後進行 Windskill Project，同時發展永續能源課程 Level 3 Course，目前加入 Power Cluster 的合作關係。

圖 7、參訪 Northumberland College

(五)參加 PRIMaRE 海洋能活動—SEA opportunities for enterprise（A 團）

■ 時間：10 月 7 日（星期三）

■ 參訪紀要：

代表團的大部分成員於本日前往普利茅斯(Plymouth)，參加 PRIMaRE (The Peninsula Research Institute for Marine Renewable Energy) 舉辦的海洋能技術活動，主題為〝SEA Opportunities for Enterprise〞。

PRIMaRE 為普利茅斯及愛塞特大學(Universities of Plymouth and Exeter) 共同設立，並由英格蘭西南區發展局 South West Regional Development Agency (SWRDA) 提供資金而成立的機

構。召集了世界級的研究學者，以其專業來深耕海洋能源領域的研究。其目標是成為領導全球海洋能源領域的研究發展與創新，並提供整合性的訓練及顧問服務。主要的業務範圍有：執行聯合訓練和研究專案、直接與 Wave Hub 海洋能發電場及相關設備研發廠商合作、研發創新並導入商業模式、提供技術移轉及顧問服務。

此活動讓產業相關業者、投資者及學術機構瞭解 PRIMaRE 如何支持海洋能源領域的成長與機會，亦認識此機構及其研究領域，並進一步得知 Wave Hub 的最新開發狀況。同時，可認識更多海洋能產業相關專業人士及社群，且與 PRIMaRE 團隊討論商業合作的機會。

圖 8、PRIMaRE 活動現場參與情況

(六)參訪 Centre for Process Innovation Ltd. (B 團)

■ 時間：10 月 7 日（星期三）

■ 英方會談人員/職稱：

1. Dr. Chris Dowle / Commercial Director
2. Mr. Steven Broome / Business Manager, Low Carbon Energy
3. Mr. Keith Gaunt / Design Engineer
4. Mr. Jonathan Kearney / Catalyst Development Scientist

■ B 團成員：工研院能環所曹芳海組長、中興電工機械公司吳啟斌處長、美菲德公司徐志彬總經理、工研院能環所鄭孟寧等四位。

■ 參訪紀要：

Centre for Process Innovation Ltd. (CPI) 為一研究機構，成立於 2008 年，由兩個英國政府機構合併而成，分別是位於 Teesside 的 Centre for Process Innovation (CPI)，以及在 Newcastle upon Tyne 的 Centre for Nanotechnology, Microtechnology and Photonics (Cenamps)。CPI 在製程及製造領域提供各項相關產品及服務，並回饋東北英格蘭就業市場及經濟的發展。CPI 所提供的服務有：(1)透過共同開發的管理模式，提供全球商業團體在製程創新、顧問及研發方面的服務；(2)透過公眾資助，建立新興科技領域方面的研究團隊及專案；(3)透過策略聯盟及衍生企業的模式，成立新創公司。

會談由雙方成員分別自我介紹後展開，首先由 CPI 的 Mr. Steven Broome 概要介紹公司的主要業務與產品，同時進行雙向問答討論，接著美菲德公司徐總經理及工研院曹組長先後簡介公司及研發產品，最後由 CPI 人員帶領本團成員前去參觀其低碳能源發展中心(Low Carbon Energy Development Centre)、燃料電池實驗室(Fuel Cell Labs)及相關設備，進行試驗研究的解說與討論。

圖 9、Centre for Process Innovation Ltd. (CPI)討論會議

圖 10、參觀 CPI 的實驗室及燃料電池告示牌

(七)參觀 Energy Solutions Expo 2009 展覽

■ 時間：10 月 8 日（星期四）10：00～12：00

■ 參觀紀要：

Energy Solutions Expo 2009 在倫敦 Olympia 展覽館舉行，展覽主題為能源管理與能源相關產業。活動展示包括產品、服務及創新等，以提升能源目標，及建築和組織的能源效率為主，提供參觀者與許多業界專業人士面對面的機會，也可在企畫及需求上與供應商交流，此展覽亦傳達減少能源價格提高對公眾事業及私人企業的衝擊。此次 Energy Solutions Expo 2009 有達 100 家公司

參展，在替代能源的產品、服務及創新業界領先的供應商和提供者，提供讓企業永續經營的機會。直接從產業界專家學習，認識產品與創新的行動，將幫助企業更有效率及效益。

圖 11、Energy Solutions Expo 2009 展場現況

(八)ITRI 與 Romax Technology Limited 簽訂合作備忘錄

■ 時間：10 月 8 日（星期四）13：30～13：40

■ 雙方參與人員：

- 台方簽約代表：工研院機械所童遷祥副所長
- 英方簽約代表：Romax Technology 公司董事長 Dr. S. Y. Poon
- 台方見證代表：經濟部能源局葉惠青局長
- 英方見證代表：英國能源暨氣候變遷部 Mr. Richard Brooks / Head of Business Development Renewables Deployment Team of DECC

■ 簽約儀式紀要：

Romax Technology 公司為傳動系統、變速箱和軸承領域提供技術諮詢、設計及軟體產品，擁有專家工程團隊和概念先進的軟體，也有豐富實際設計經驗和優秀分析能力。為了加速國內風力機技術之開發，自 97 年起工研院機械所與英國 Romax 公司積極展開接洽與討論，為了促進未來雙方更為緊密之合作關係，藉由舉辦「台英第四屆再生能源交流合作圓桌會議」之機會，於兩國

負責再生能源推動的官員見證之下，雙方簽署合作備忘錄，主要以風力機傳動系統設計技術、傳動測試平台設計與分析為簽約合作項目。

圖 12、工研院童副所長與 Romax 公司 Dr. S. Y. Poon 簽訂 MOU

(九)拜會 Department of Energy and Climate Change

- 時間：10 月 9 日（星期五）10：00～12：00
- 英方會談人員/職稱：Mr. Duarte Figueira / Head of Renewables Deployment Team
- 拜訪紀要：

拜會英國能源暨氣候變遷部，是屬於官方層級的訪問，瞭解英國於再生能源政策制定的重點，政府於實行面的目標與策略，也進一步討論到溫室氣體減量等相關議題。

英國能源暨氣候變遷部（Department of Energy and Climate Change，簡稱 DECC）成立於 2008 年 10 月，為整合能源政策與減緩氣候變遷政策的主管部門。

全球面臨著前所未有的挑戰，包括環境、經濟及未來能源供應的安全，現在所做的決定將會影響整個地球及下個世代的生活方式，英國能源暨氣候變遷部的使命正是克服這些挑戰。這個新機構的成立，正反映著能源政策與氣候變遷之間不可分離的關係，三分之二的溫室氣體排放來自於我們使用的能源，因此能源與減緩氣候變遷兩項政策的決定，不可不考慮相互之間的影響與衝擊。

DECC 負責制定英國能源政策，代表英國處理全球氣候變遷協定的各項事宜。其中四項重要政策領域如下：

- 全球氣候變遷及能源—代表英國處理全球氣候變遷的各項事宜，達到 2009 年 12 月在哥本哈根大會國際協定的規範。由於英國屬於大量進口能源的國家，也想要確保能源供應無虞且來源多樣化。
- 英國能源供應—英國享有多樣化及低碳能源的結合，並透過適當的市場架構以確保價格的競爭力。
- 支持消費者—我們希望在協助消費者節省經費及拯救環境的同時，亦提升能源效率且不虞匱乏。

- 低碳的英國—透過碳預算及其他機制，致力於協助英國朝向低碳經濟前進。

圖 17、拜會英國能源暨氣候變遷部(DECC)

五、心得與建議

(一)英國政府為加速新能源技術之研發，促進永續能源經濟的成長，並致力於發展再生能源電網整合及低碳發電技術,設立新及再生能源中心(NaREC)，並獲歐盟金援資助。此一研究機構可針對風力、波浪發電、潮汐發電及太陽光電等再生能源進行技術研究發展，並研擬相關政策以促進英國新及再生能源能源產業。NaREC 與全球的跨國績優公司、中小型企業、各大學研究機構合作，並提供產業和工程顧問服務、測試設備、研發以及商業支援。該機構亦提供場所，接受各公司將其原型產品設置於 NaREC 內進行測試,因此吸引不少公司前來。美國風機廠商 clipper 就因 NaREC 提供所需條件與協助，並著眼於歐洲市場，就近將該公司之歐洲總部設於 NaREC 內，目前正進行 10MW 離岸風機之研發。

(二)我國政府亦可考慮效法英國措施，由政府成立類似 NaREC 之國家級實驗室，針對再生能源技術進行研發，並對外提供協助及招商，對於再生能源推動及落實技術生根發展應有助益。例如離岸風力發電成本龐大，業者無法負擔失敗的巨大風險，因此風力機在設置前必須經過完整的有效性測試，以確保大型風機葉片之安全及可靠性。NaREC 擁有先進的葉片測試設施、內部技術和原型開發能力，可在一個獨立且保密的環境下,為製造商提供驗證新設計和提高可靠度的機會。我國若設置類似 NaREC 的實驗室，除可協助解決我國推動離岸風電所面臨之技術問題,並可提供國內及亞洲地區風機產業相關服務。

(三)英國海洋能源相當豐富，亦為全球海洋能技術先進國家，加上政府積極挹注經費與政策鼓勵，在波浪發電(Wave Energy)及潮流發電技術(Tidal Current Energy) 的研發更是居世界領先之地位。然而英國海洋能也有失敗的案例,一家蘇格蘭公司 Pelamis 為全球首個將海浪發電技術實現商業營的公司，2008 年該公司在葡萄牙

海域建立阿古薩朵拉海浪公園實地設置機組,但4個月後在生產電力併網時卻面臨技術難題，雖然 Pelamis 將其歸因於「在軸承上的過度消耗」,將機組拖回岸上試圖修改,然而問題迄今並未解決,且該計畫一直存在很大的資金問題,目前計畫已幾近停滯。雖然很多人對於海浪發電技術的潛力抱樂觀態度,即使像英國政府投入大量資金輔導,但新技術的發展仍有諸多問題有待突破及實證,故本公司未來投入海洋能之計畫與步調亦須相對謹慎。

(四)英國 Northumberland 大學最初於 2004 年底開始與多個公司及機構合作風力訓練課程,2005 年 2 月則協助發展風力引導課程(Wind Pilot Programme)，一開始以大型陸域風場的技術人員訓練為目的,吸引了約 20 個組織參加,也得到大量有建設性的批評與回饋,大多數要求更多實際的活動及練習,回饋亦有來自產業和允許進入歐盟計畫的德國教育學者等關鍵參與者。該訓練課程雖未完備,但對歐洲之風力維護人員培訓已見成效。反觀我國未來亦有大量風力機組開始商轉,然而相關維護技術人員並未配合規劃養成,故本公司除可考量派員參與該大學之風力技術人員訓練課程外,亦可考慮於台電內部建置訓練機構。本公司目前商轉及興建中之風力機組共162 部，加計規劃中之陸域及海域風機，數量相當可觀，因應未來大量之風機維護工作，本公司相關部門應儘早規劃人員訓練，以培養維護技術能力，亦可參採該大學之訓練模式,在地面上設置風機機艙，拆解相關電子及機械部件，讓技術人員可以在地面實際操作，模擬維護工作，另因應未來離岸風機維護，亦須增加海上安全之訓練課程,如此才能對於本公司未離岸風力發展充分預作準備。

六、附件及參考資料

附件一、第四屆台英再生能源圓桌會議討論議題

《Wind Power 1》

提案單位 Proposer	工業技術研究院 機械與系統研究所 Mechanical and Systems Research Laboratories of the Industrial Technology Research Institute
討論題綱 Discussion Issue	離岸風力機傳動系統技術之發展 Development of the Offshore Wind Turbine Drive Train Technology

說明：

風力機承受複雜的風力，這是風力機傳動元件容易破壞的因素之一，而離岸風力機將承受更加惡烈的負載。另外，分析模型不夠精確、軸承選取不當及動態效應之影響亦是風力機傳動元件損壞的原因，故必須建立整合式的風力機傳動系統模型，此模型需具備彈性與動態特性，同時需考慮非線性風力、非線性控制作用及非線性海浪負載之交互作用所產生之綜合效應，才能更精確地掌握離岸風力機傳動系統之特性,以提高離岸風力機傳動系統之可靠度。

Explanation:

The complicated loading is a reason resulted in component failures of onshore wind turbine drive train. This problem will be more serious for offshore wind turbine drive train. The other reasons induced wind turbine drive train failures are inaccurate models, incorrect bearing selection, and dynamic effects of wind turbine. Considering the non-linear wind loading, non-linear control actions, and non-linear wave loading, the integrated time-domain model with flexible and dynamic structure must be developed to simulate the behavior of offshore wind turbine drive train and to improve the reliability of offshore wind turbine drive train.

合作內容：

1. 離岸風力機傳動系統設計技術
2. 離岸風力機傳動系統模擬技術

Details of Cooperation:

1. Design technology of Offshore wind turbine drive train.

2. System simulation technology for Offshore wind turbine drive train.

建議合作方式：

1. 研討會

   雙方共同舉辦研討會，邀請相關的台、英雙方學者與廠商討論風力機傳動系統設計技術。

2. 技術引進

   今年，我方已經引進英國 Romax 公司有關風力機傳動系統測試平台技術。Romax 公司在風力機傳動系統動態模擬具有專門之技術，並有相關的模擬軟體。希望透過技術引進的方式，協助台灣建立風力機傳動系統動態設計技術。

Suggested Method of Cooperation:

1. Seminar

   Co-organize seminars in which scholars from both Taiwan and UK will be invited to discuss the topics include the design technology of Offshore wind turbine drive train.

2. Technology Transfer

   This year, we already transferred test technology for wind turbine drive train from Romax Corp., UK. Romax has also been an expert in the dynamic simulation for wind turbine drive train. We hope to propose a new technology transfer project for establishing the related technologies in Taiwan.

	台灣 Taiwan	英國 UK
建議對談/合作對象 Suggested Discussants/ Potential Cooperators	工研院(ITRI) 東元電機(TECO) 台朔重工(FHI)	Romax Univ. of Manchester

《Wind Power 2》

提案單位 Proposer	工業技術研究院機械與系統研究所 Mechanical and Systems Research Laboratories of the Industrial Technology Research Institute.
討論題綱 Discussion Issue	離岸風電場開發 Development of the offshore Wind Farm

說明：

英國 Talisman 公司在碧翠西(Beatrice)離岸風電場安裝了兩支 5MW 風力機，距離蘇格蘭東岸 25 公里，對安裝於深水區之離岸風力機進行測試。台灣的台灣電力公司規劃在澎湖離島外海規劃離岸風電場(包括示範計畫)，希望能參考碧翠西離岸風電場。故擬請教:

(1)在 O&M 方面有無特別規劃？運轉至今，在 O&M 方面建立了哪些資料庫，如何進行方析？

(2)請說明離岸風驗場的 O&M 成本分析模式.

(3)環境評估進行哪些調查?

(4)是否與漁業或漁民產生衝突？如果有，如何補償？

(5)此計畫接受 EU 的經費補貼(4100 萬歐元)，故未來的發電收入是否需回饋?

(6)在英國，如果示範計畫是由政府出資及推動，未來風電場的產權及營運是否屬於政府或轉移至民間？

Explanation:

To test the wind conversion technologies at deep waters offshore, Talisman (UK) installed two 5MW wind turbines in Beatrice offshore wind farm 22km off the northeast coast of Scotland. In Taiwan, Taipower company is planning the offshore wind farm (including demonstration program) off the southeast coast of the Penhu Islet and would like to learn the following issues from the experiences of the Beatrice project:

(1) The O&M plan specific for the offshore wind turbines and the database constructed for the analysis of the O&M activities.

(2) The cost model for O&M.

(3) The environment impact analysis.

(4) Any occurrence of the conflicts between this project and the local fishery industry or fishermen and the approaches to resolve the conflicts.

(5) Based on the background that EU financed the Beatrice project by 41million EURO. Does Talisman need to feedback EU from the sales of the electricity production?

(6) In case that a wind farm project is funded by the government or EU, Will the government or EU legally own the wind farm or will the ownership be transferred to the private sectors?

可能合作內容：

1. 離岸風場開發示範
2. 離岸風力機系統設計技術

Content of Potential Cooperation:

1. Offshore wind farm demonstration
2. System design technology of the offshore wind turbine

建議合作方式：

1. 研討會

   雙方共同舉辦研討會，邀請相關的台、英雙方學者與廠商討論風力機系統設計技術。

2. 技術引進

   過去兩三年，我方已經與英國 Garrad Hassan 公司進行控制系統技術以及離岸系統的可行性評估技術引進。跟 Romax 也進行傳動系統設計的技術引進。希望能繼續透過技術引進的方式，協助台灣建立離岸風場開發相關技術。

Suggested Method of Cooperation:

1. Seminar

   Co-organize seminars in which scholars from both Taiwan and UK will be invited to discuss the topics include the design technology of Offshore wind turbine system.

2. Technology Transfer

   In the past three years, we already transferred control system technology and offshore wind system feasibility study from Garrad Hassan Corp., UK. And also transfer drive train design technology from Romax. We hope to propose a new technology transfer project for establishing the offshore wind farm development technologies in Taiwan.

建議對談/合作對象 Suggested Discussants/ Potential Cooperators	台灣 Taiwan	英國 UK
	工研院(ITRI) 東元電機(TECO) 台朔重工(FHI)	Romax Univ. of Manchester

《Wind Power 3》

提案單位 Proposer	工業技術研究院能源與環境研究所 Energy and Environment Laboratories, Industrial Technology Research Institute
討論題綱 Discussion Issue	台灣離岸風力發電推動 Promotion of Offshore Wind Development in Taiwan

說明：

離岸風力電場施工運維供應鏈建置策略規劃

- 英國離岸風場開發，針對海事工程施工機具之供應鏈建置曾遭遇那些策略面問題？有什麼重要的經驗可以與台灣分享？
- 英國在建置離岸風場運轉維修船隊的過程，曾面臨哪些重大問題？有什麼重要的經驗可以與台灣分享？

Explanation :

In establishing supply chains of construction, operation and maintenance for offshore wind farms

- When developing a supply chain of marine construction and its equipment, what kind of strategic problems were countered in UK? What is the most important experience during dealing with those problems?
- What are the essential issues in developing a fully-operational self-sufficient maintaining fleet for offshore wind farms? Could you share some experiences with Taiwan?

合作內容或建議合作方式：

1. 英方協助台灣進行施工運維供應鏈建置策略規劃
2. 台灣相關單位派員至英國公司長期參與離岸開發計畫，學習全面性之規劃、設計及施工技術。

Details of Cooperation or Suggested Method of Cooperation :

1. UK assists Taiwan with strategic planning for establishing supply chains of marine construction, operation and maintenance in offshore wind development.
2. If possible, UK and Taiwan initiate a long-term training program by sending Taiwan engineers to UK to join the offshore wind development projects.

《Marine 1》

提案單位 Proposer	工業技術研究院 能源與環境研究所 Energy and Environment Research Laboratories, Industrial Technology Research Institute
討論題綱 Discussion Issue	波浪發電之開發與產業推動 Wave energy development and industry impetus

說明：

- 台灣波能之高潛能區約在 10~15kW/m 之間，在這樣之波能條件下，能否借由選擇合適波浪發電設備之容量來增加開發之經濟效益？
- 是否透過成立台英波能開發推動小組，輔助本所與 Aquatera 公司已經在進行的合作，推動英國設備廠商來台佈放一組合適之設備，以驗證其安全性，並進而協助台灣波浪潛能之利用與開發技術之建立。
- 在波浪發電技術尚未成熟與穩定商轉時是否就該進行相關產業的推動? 該如何進行波浪發電相關產業的推動? 可能的阻力有哪些?

Explanation:

- Taiwan has wave potential energy about 10~15kW/m. Can the economic benefit be increased by choosing the suitable WEC device for Taiwan?
- Should a Taiwan-UK marine energy promotion group be formed to facilitate the possible cooperation between both sides?
- Should WEC industry impetus take place now when the maturity and the commercialization of the technologies are not quite ready? How should the impetus be implemented? What are the obstacles lay ahead?

合作內容或建議合作方式：

- 成立台英海洋能開發推動小組專注提升雙方在海洋能開發上的合作. 英方提供裝置、 安裝佈放、操作維護、連網、及整體開發規劃等技術, 我方可提供發電機、電子科技、海洋工程、數值模擬、浮體及錨碇運動分析、資訊、與 GIS 方面的技術。
- 參與英國波浪發電裝置開發廠商針對台灣海況進行波浪發電裝置設計與建造，並引進在台灣海域進行安裝佈放與測試。
- 與英國學術單位進行波浪發電相關技術交流與學者及學生交換計畫。

Details of Cooperation or Suggested Method of Cooperation：

- Form a Taiwan-UK marine energy promotion group to facilitate the possible cooperation between both sides. UK can provide know-how on the device, anchor techniques, operation and maintenance, grid connection, and farm planning, etc., and Taiwan can provide the technologies on generator, electronic parts, ocean engineering, floating and anchoring analysis, numerical simulation, information technology, and GIS, etc.
- Join UK WEC development companies to design and build the specific device for Taiwan's wave climate. Import the device to Taiwan for deployment and testing.
- Start the scholars and students exchange programs between academic and research units in Taiwan and UK.

《Fuel Cell 1》

提案單位 Proposer	工業技術研究院 能源與環境研究所 Energy and Environment Research Laboratories, Industrial Technology Research Institute
討論題綱 Discussion Issue	質子交換膜燃料電池示範驗證與次世代技術研究合作 PEMFC Demonstration/Validation & Next-generation Technology Research Cooperation

說明：

質子交換膜燃料電池於備用電力、特輸運具、熱電共生等市場應用機會逐漸顯現，不僅可具經濟效益，而且節能減碳效果亦經初步實證，如果能藉由提升社會與使用者接受度，擴大市場規模、降低成本，將可為大規模交通應用及氫能普及奠定堅實基礎。

Explanation:

PEMFC applications in backup power, specialty vehicle and combined heat and power markets have started to show good economic and energy-saving/ emission reduction potentials in preliminary field trials. Public and user acceptance of this technology must be increased further to reach the scale of economy, which can be a must-have foundation for the transition to hydrogen transportation applications.

合作內容或建議合作方式：

- 雙方業者(可含學研界)合作，分別於台灣與英國(或歐盟)進行 PEM 燃料電池系統示範驗證
- 雙方業者(可含學研界)合作開發適用於歐盟市場之 PEMFC 利基應用產品
- 雙方學研界及業者共同進行耐久或次世代關鍵技術研發(例在 FP7 架構下)
- 台灣引進英國關鍵技術

Details of Cooperation or Suggested Method of Cooperation：

- Both sides (industry/R&D Inst./Academia) collaborate to conduct PEMFC systems demonstration/validation in Taiwan and UK
- Both sides (industry/R&D Inst./Academia) collaborate to carry out joint development of PEMFC niche products for the EU market
- Both sides (R&D Inst./Academia/industry) collaborate to conduct investigation into PEMFC durability issues and/or next-generation PEMFC technology (e.g. under the FP7)
- Key technologies transfer from UK

《Fuel Cell 2》

提案單位 Proposer	美菲德有限公司 M-FIELD Energy LTD.
討論題綱 Discussion Issue	燃料電池備用電力系統設置 Fuel Cell Back-Up Power system Verification Project

說明：

燃料電池備用電力系統在國際能源市場上逐漸嶄露頭角，通訊產業已逐漸開始改用燃料電池系統作為備用電力來源。英國具備國際行銷能力，台灣則具備優異硬體製造實力，英國與台灣有機會藉由共同合作產品實證計畫，完成系統運轉數據收集，扶持兩國產業茁壯並合作開發他國市場。

Explanation:

Fuel Cells have been proven the superior solution for Back-up Power. The communication industries have started installing Fuel Cell System as the next generation back-up power source. United Kingdom possesses excellent international marketing ability, while Taiwan has strong manufacturing and system integration capability. UK and Taiwan can establish the Fuel Cell system testing and verification projects together. With the data proved by the projects, industries in both nations can collaboratively develop global market opportunities.

合作內容或建議合作方式：

英國政府開設燃料電池不斷電系統示範驗證計畫，以電信產業基地台或交換站等作為設置據點，開放台灣系統廠商參與合作，共同建立產品標準及相關規範。

Details of Cooperation or Suggested Method of Cooperation:

UK government establishes Fuel Cell UPS system demonstration and verification projects for telecom cell site, switching centers etc. Before field test, local lab-test is necessary, for example CPI lab certificate. After long-term & verification with certain quantity, we can build industrial standard and certificate in fuel cell UPS product. Besides, UK has ability to expand it to IEC or other worldwide standard.

《Fuel Cell 3》

提案單位 Proposer	中興電工機械股份有限公司　新能源研發中心 Renewable Energy RD Center, Chung-Hsin Electric & Machinery MFG. Corp.
建議對談/合作對象 Suggested Discussants/ Potential Cooperators	Ceres Power

說明：

- Ceres 熱電共生產品是設計來替所有暖房、熱水，以及一個傳統英國家戶需求的大部分電力來發電而產生的
- Ceres 能夠以其科技實力打開龐大的微熱電共生市場

Explanation :

- ✓ The Ceres CHP product is designed to generate all of the heating and hot water and the majority of the electricity needed by a typical UK home.
- ✓ The vast market for mCHP systems can be opened up by Ceres Power's technology.

合作內容或建議合作方式：

- 透過使用液化石油氣的重組器科技交流，建立愈趨緊密的商業關係
- 取得 Ceres 在英國市場一面控制平衡系統零組件供應鏈，一面運用其鍋爐商業夥伴供應鏈資源的 Know-how

Details of Cooperation or Suggested Method of Cooperation :

- ✓ Close-knitted business relationship established through LPG-based reformate technology development.
- ✓ Gaining know-how of controlling BoP component supply chain while using boiler partner's supply chain for standard parts.

《Fuel Cell 4》

提案單位 Proposer	中興電工機械股份有限公司　新能源研發中心 Renewable Energy RD Center, Chung-Hsin Electric & Machinery MFG. Corp.
建議對談/合作對象 Suggested Discussants/ Potential Cooperators	Intelligent Energy

說明：

- IE 的燃料電池堆和系統結合了新穎的熱流管理技術以及整合性加濕金屬雙極板的結構
- IE 的先進燃料電池電力系統是比傳統燃料電池系統更為精簡的，在多種應用上面都能輕而易舉地整合進去

Explanation :

- ✓ Intelligent Energy's fuel cell stacks and systems have been designed from first principles and combine novel fluid and thermal management techniques and integrated humidification with metal bi-polar plate architecture.
- ✓ IE's advanced fuel cell power systems are more compact and far simpler than conventional fuel cell systems and are easily integrated within a diverse range of applications.

合作內容或建議合作方式：

- 透過我們與 IE 簽訂代工合約，合理接觸其整合性加濕及創新的冷卻系統技術，以資往後電堆模組的組件大幅減少，亦篩減大部分平衡系統組件，以其最終大幅延長燃料電池持續運轉時數。

Details of Cooperation or Suggested Method of Cooperation :

- ✓ Leveraging IE's integrated humidification and innovative cooling system through OEM contracts signed, which further reduces our future component count within the stack, and eliminates much of the conventional BoP components.

《Fuel Cell 5》

提案單位 Proposer	中興電工機械股份有限公司　新能源研發中心 Renewable Energy RD Center, Chung-Hsin Electric & Machinery MFG. Corp.
建議對談/合作對象	Johnson Matthey

說明：

- JM 在燃料電池的應用，偏向娛樂及軍事圈的切入，其電池充電系統的研發也已進入後期
- 英國政府對定置式燃料電池的補助，對於都會區天然氣熱電共生燃料電池市場有助益
- 市場對於低碳及二氧化碳封存的關切，讓 JM 重組器科技發展加速
- 發電廠排放控制系統的完整發展

Explanation :

- ✓ JM's application preferred leisure and military plans, and its battery charging system R&D has already entered late stages
- ✓ The UK gov't subsidy of stationary fuel cells would be beneficial to LPG-based urban CHP fuel cell market
- ✓ Focus on low-carbon and CO2 sequestration should accelerate demand for reforming technologies
- ✓ Heavy proportion of emissions control system for power plants

合作內容或建議合作方式：

- 貴金屬觸媒奈米薄塗層的供應或技術轉換，有助於重組器成本的大幅降低
- 重組器的購置，對於在台灣裝置的碳足跡減少的成就會有相當助益，因其「永續 2017 遠見」計劃已有效在製造流程供應鍊中有效壓低碳排放
- JM 的住宅熱電共生裝置，及軍事備用電源的應用，皆可做運轉經驗傳授

Details of Cooperation or Suggested Method of Cooperation :

- ✓ Seek for supply or tech transfer of precious metal nano-coating for catalyst, which is helpful for lowering cost of reformate technology
- ✓ Procurement of reformer, which would assist lowering carbon footprint when FC system is deployed, since JM's "Sustainability 2017 Vision" has effectively reduced carbon footprint during the upstream value chain
- ✓ Experience exchange of residential CHP and military BPS

附件二、Opportunity in Offshore Wind Energy (機械所引言簡報)

附件三、Ocean Wave and Current Energy Development in Taiwan

(能環所引言簡報)

附件四、PEMFC Demonstration/Validation & Technology Development in Taiwan (能環所引言簡報)

附件五、UK Wind Energy (Wind Prospect Group 引言簡報)

附件六、The State of the Global Fuel Cell Industry and UK Expertise (Fuel Cell Today 引言簡報)

The Fourth Taiwan-UK Renewable Energy Round Table Meeting

Opportunity in Offshore Wind Energy

Dr. Alex Tong
Deputy General Director, MSL/ITRI
October 8, 2009

Policies encouraging offshore wind Energy in Taiwan

- Wind energy selected as one of the key renewable energy industries for Taiwan in 2007 SRB meeting
- Wind energy identified as one of major industries to be supported by government R&D fund in National Energy Conference 2009
- "Renewable Energy Bill" passed in June, 2009, providing new incentives for renewable energy deployment, as well as technology development

Goals for Renewable deployment in Taiwan

■ **Renewable Energy shall contribute 15% in terms of installed capacity by 2025.**

Renewables \ Year	2008		2010		2015		2025	
Installed Capacity	Installed Capacity (MW)	Ratio (%)	Installed Capacity (MW)	Ratio (%)	Installed Capacity (MW)	Ratio (%)	Installed Capacity (MW)	Ratio (%)
1.Hydropower	1,939	5.05	2,168	5.7	2,261	5.1	2,500	4.4
2.Wind Power	**358**	**0.93**	**980**	**2.6**	**1,480**	**3.4**	**3,000**	**5.3**
3.Photovoltaics	4.08	0	31	0.1	320	0.7	1,000	1.8
4.Geothermal	---	---	---	---	10	0.0	150	0.3
5.Biomass	772	2.01	741	1.9	850	1.9	1,400	2.5
6.Fuel Cell	---	---	---	---	50	0.1	200	0.4
7.Marine Power	---	---	---	---	1	0.0	200	0.4
Total	**3,073**	**8.0**	**3,910**	**10.3**	**4,972**	**11.2**	**8,450**	**15**

＊Source：Bureau of Energy, MOEA

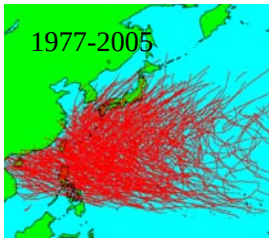
Wind Resource、 Challenge and Status in Taiwan

■**Rich in wind energy, at least 4,800MW potential. (Onshore: 1,600MW, Offshore: 3,200MW)**

■**Operating wind projects statistics**

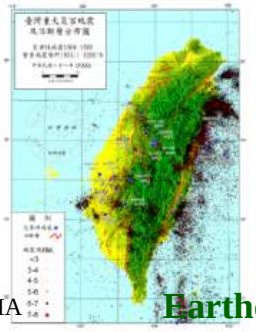
Update：2009/08

Wind Farm	**17**
Wind Turbines	**200**
Acc. Capacity	**380MW**
Annual Production	**1,000 GWh**
Supply	**250,000 households**

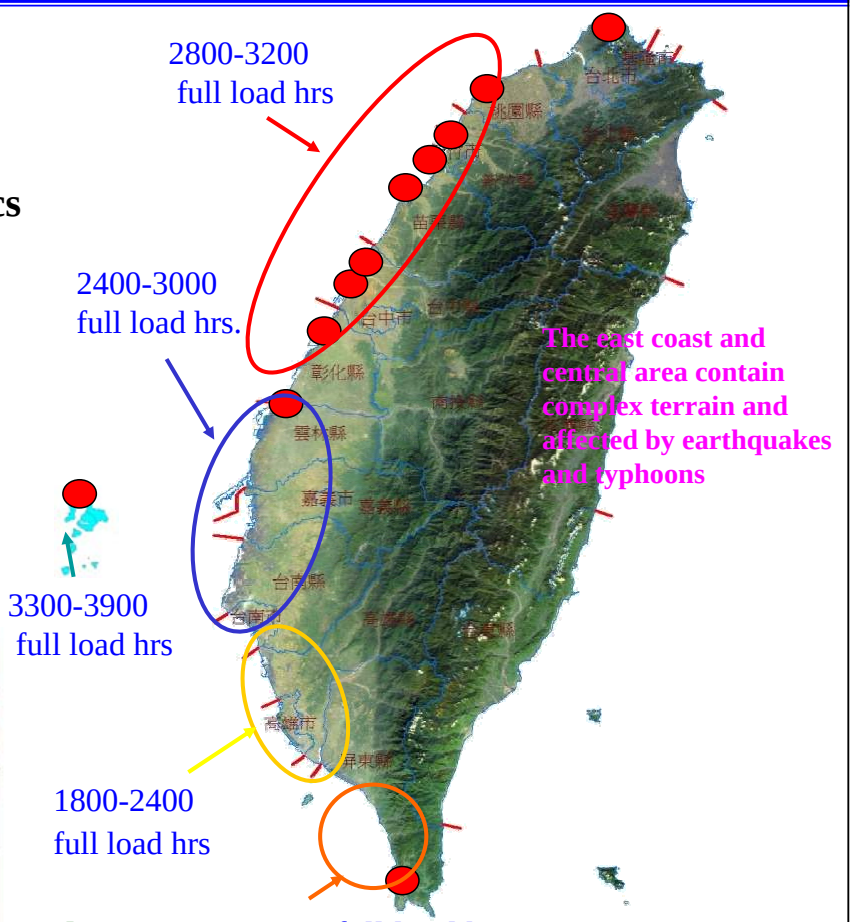


Typhoon

Source：Japan Meteol. Agency, JMA



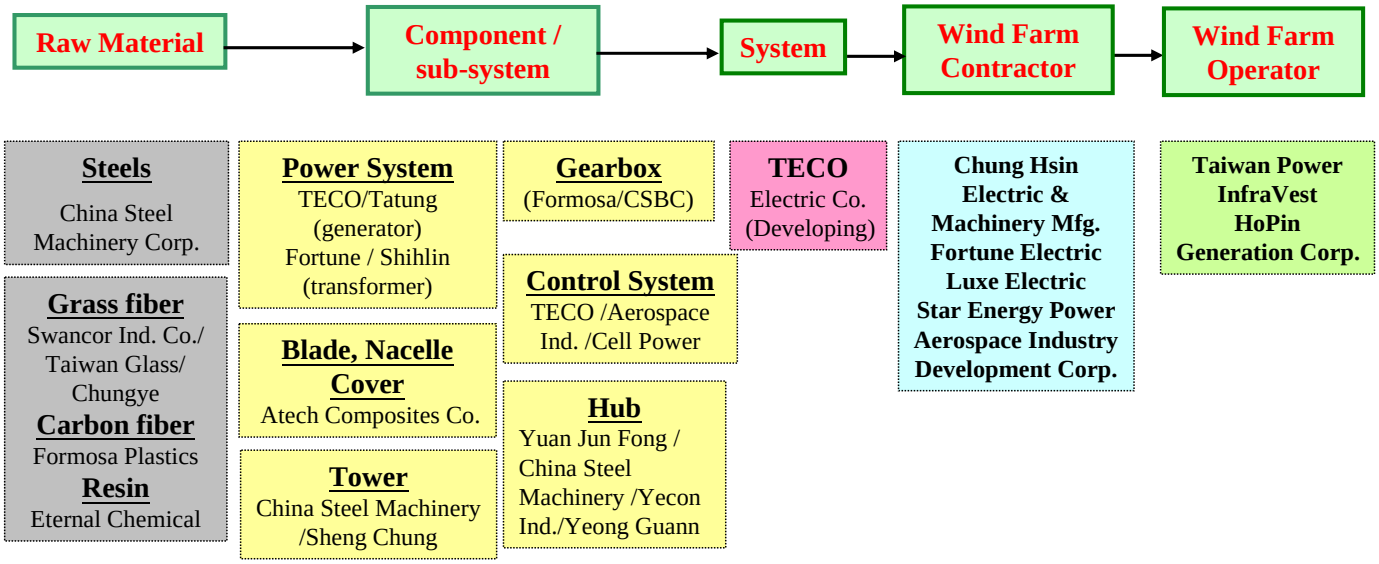
Earthquake



Source：ITRI

Status of Wind Power Industry in Taiwan

- Complete wind turbine supply chain established.
- Cross-strait linkage providing a growth-engine for the industry

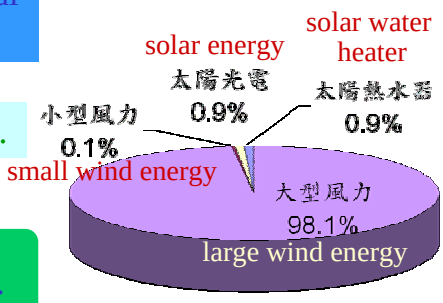


Source：ITRI (2009/10)

Opportunity--Peng-Hu to be a Low-Carbon Island

a low-carbon show case, an international vacation attraction.

Image	Taiwan first low-carbon island, enhance international image, transplant experience to main island.
Energy	Renewable Energy supplied of over 50% in 4 years..
Resource	Maximizing water resource utilization, zero waste.
Industry	Tour and green energy industries for local economy revival.



Offshore Field around Penghu Archipelagoes

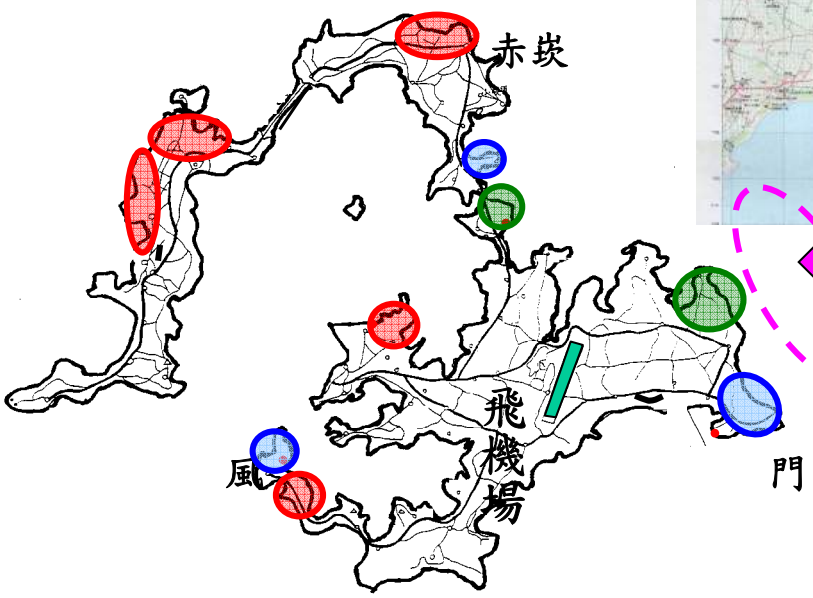
- Average annual wind speed : 7.5~8m/s; the capacity factory of onshore ChunTun wind farm : 45%
- Undersea power cable between Penhu and Yunlin with transmission capacity of 400MW (161kV) to be commissioned in 2014.
- Water depth about 20m providing a good site for establishing offshore wind farms.

澎湖白沙島之中屯風電場: Enercon E40/600kW × 8

Offshore Wind Farm Demonstration Project under Evaluation

Onshore Project

Operating/ Under construction	10.2MW
In planning by TPC	42MW
In Planing by Private sector	32MW



Offshore Wind Farm planed by TPC

Offshore Wind Farm Demo Project to lead the way

Party invited：
Mott MacDonald、BMT、GH

Collaboration Proposal

■ Offshore Wind Farm Demonstration (Development, Building, Operation, Risk evaluation…)

Contracted：

- BMT /Guidelines for the Feasibility Study of Offshore Wind Farm
- GH /Feasibility Study for Offshore Wind Turbine System Design

Potential Contracts： Offshore Wind Farm Demonstration Project

■ Technology Cooperation

Contracted：

- GH /Bladed Software； Control System
- Romax /RomaxDesigner Software ; Gearbox Test Rig Design

Potential Contracts：

- System design of the offshore wind turbine
- Designing large offshore wind turbine drive train
- design and operation of offshore construction vessel

■ Industry Cooperation

- Components OEM
- Industrial cooperation and information exchange through the channel of Taiwan and UK wind energy association.

UK  Taiwan

THANK YOU FOR YOUR ATTENTION

2009 Taiwan-UK Renewable Energy Round Table Meeting

Ocean Wave and Current Energy Development in Taiwan

Chih-Wei Yen
Industrial Technology Research Institute

October 8, 2009

Outlines

- Potential Area of Wave and Current Energy in Taiwan
- Tidal Current Energy Present Development
- Tidal Current Development Goals
- Wave Energy Present Development in Taiwan
- UK Aquatera Ltd. Help Determined Taiwan's WEC Development Pathway
- Future Wave Energy Development Strategy of Taiwan-UK Cooperation
- Challenges

工業技術研究院
Industrial Technology Research Institute

Potential Area of Wave and Current Energy in Taiwan

- **Potential capacities of Taiwan ocean energy**

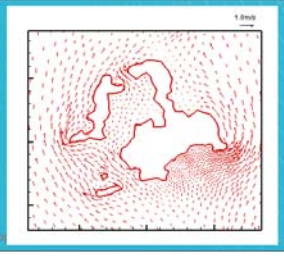
Categories	Potentials
Wave energy	10~15 kW/m
Tidal Current	0.78~1.05 m/s (Penghu Channel)
Ocean Current (Kuroshio)	1.05~1.60 m/s (Eastern offshore)

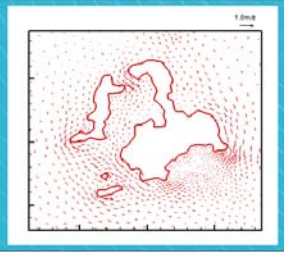
- **Potential Sites (see right diagram)**
- **Status**
  - **No practical device installed**
  - **Green laws passed in Taiwan Legislature**

工業技術研究院 Industrial Technology Research Institute

Tidal Current Energy Present Development

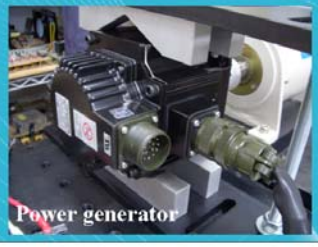
■ Tidal Current Potential Side





■ National Cheng Kung University

Testing of the vertical-axis turbine with low velocity high-torque model



究院

Tidal Current Development Goals

Stage 1: 2009-2010

On-site testing, reviewing and modifying of the Pilot Plan model machine, patent Technology transfer, commercialization planning and design of the system. Continue R&D effort on the innovative low-velocity high-torque turbine design, modifying the high-efficiency generator and establish an integral R&D testing platform.

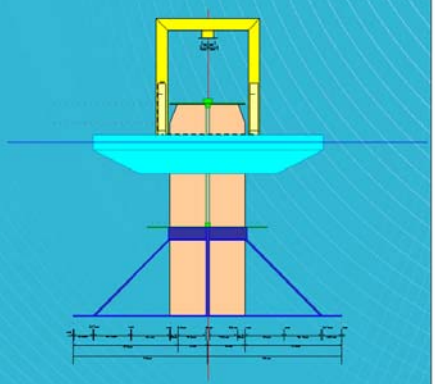
Stage 2: 2011 and after

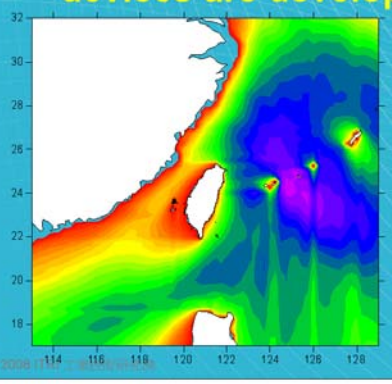
Realize technology transfer with the assistance of industry incubation center, and eventually launch commercial operation and join the renewable energy industry. Continue R&D effort on the innovative low-velocity high-torque turbine design, modifying the high-efficiency generator and establish an integral R&D testing platform.

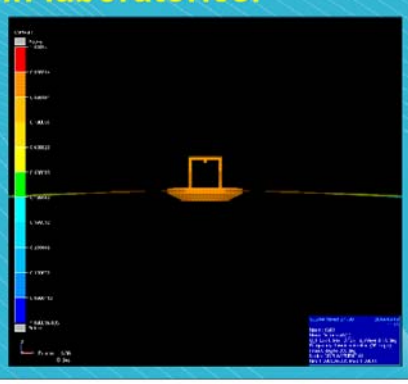
工業技術研究院
Industrial Technology Research Institute

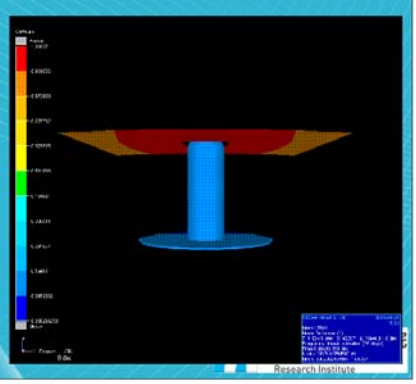
Wave Energy Present Development In Taiwan

- **Wave Energy Simulation**
  Using numerical model to calculate wave energy potential.
- **WEC Device Dynamic Analysis**
  Hydrodynamic analysis to find best/worst response conditions for efficiency analysis, mooring analysis, and structural strength analysis.
- **WEC Device**
  An OWC and some point absorbed type of devices are developing in laboratories.









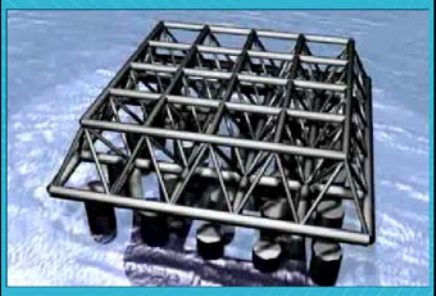
Research Institute

UK Aquatera Ltd. Help Determined Taiwan's WEC Development Pathway

Selected Pathway

Small-scale offshore test deployment of a new technology

Finalists

Ocean Navitas	Wave Energy Technologies	Manchester Bobber
		
UK	Canada	UK

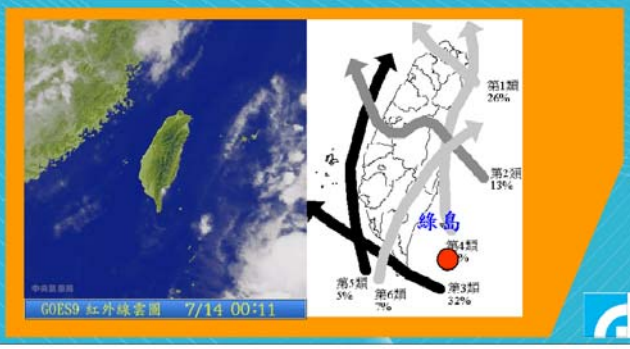
工業技術研究院 Industrial Technology Research Institute

Future Wave Energy Development Strategy of Taiwan-UK Cooperation

YEAR	Execution Strategies	Taiwan-UK Cooperation Items
2008	Technology Assessment and Selection	■ Site Characteristic Analysis ■ Technology and Device Selection ■ Next Stage Planning
2009	WEC Device Capacity Verification Domestic Research & Development Through International Cooperation	■ Engineering suitability assess. ■ Project feasibility assess. ■ Confirmation of project specific.
2010	Joint Deployment and Testing Detail Planning Domestic Device Tank Test	■ Device Design and Construction ■ Deployment Preparation Planning
2011 ~2014	UK and Domestic WEC Devices Deployment and Test Comparison	■ Device Deploy and Test ■ Device Technical Exchange ■ Domestic Device Deployment
Midterm Goals	Tens kW WEC Pilot Plant Demonstration and Operation MWs WEC Power Plant Planning	

Challenges

- **Typhoon**: Potential areas located in the path of typhoon, which makes the underwater deployment, construction and maintenance more challenge.
- **Earthquake**: Shallow earthquake in the coastal area is likely to cause sea bed pileup and dip slope collapse。
- **Bathymetry and Topology**: High potential area of Green Island Kuroshio is located in the area of water depth over 200m and with steep terrain, which make the installing and maintenance of generator more difficult.



Transform Taiwan into a Green Energy Island of safety, efficiency, purity and constancy.

Thank You for Your Attention

PEMFC Demonstration/Validation & Technology Development in Taiwan

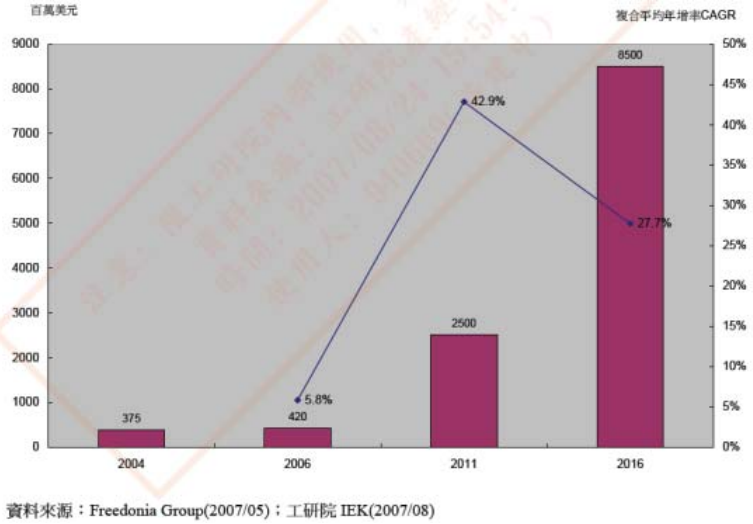
Fanghei Tsau
Energy and Environment Research Laboratories, ITRI



Taiwan-UK 4th Renewable Energy Round-table Meeting
October 8, 2009

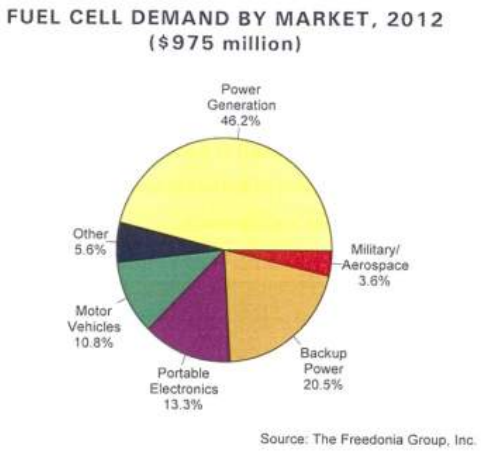
Global Trend & Status

- **Fuel cells market was projected (2007) to grow significantly after 2010**
- **Stationary applications outside of industrial sector represent the largest potential market**



資料來源：Freedonia Group(2007/05)；工研院 IEK(2007/08)

US Fuel Cells Market Projection*1



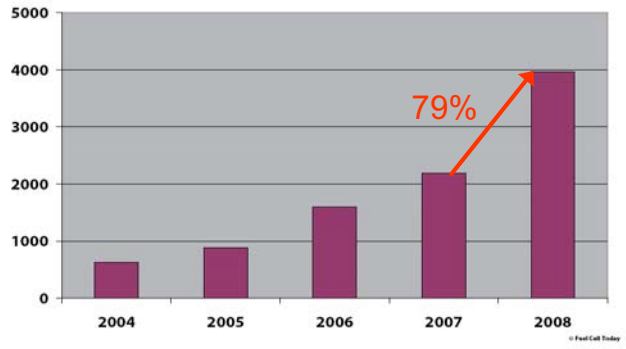
Source: The Freedonia Group, Inc.

1. 55% market share for non-industrial stationary applications in 2006
2. 40% market share projected in 2016

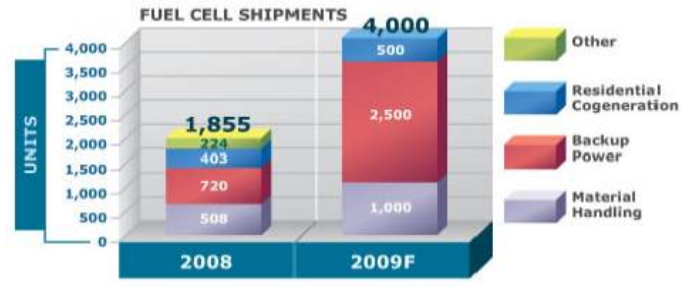
Global Trend & Status (cont'd)

- US triples its subsidy to US$ 3,000/kW or up to 30% of the overall installation cost.
- Japan begins to subsidize residential PEMFC CHP system purchase (up to 40%), projected market size exceeding US$ 200 million in 2009 (6000 units) and US$300 million in 2010 (10000 units).
- Niche markets of backup power units and forklifts could reach US$ 2 billion in 2012.

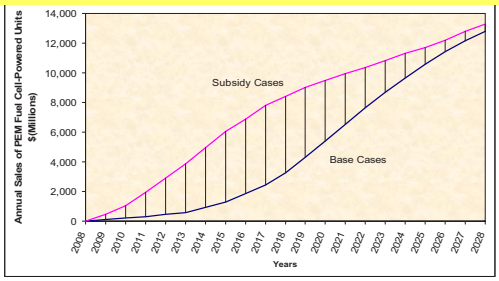
New Small (<10 kW) Stationary FC Shipments[*2]



One Year Market Projection of Ballard Co.[*3]

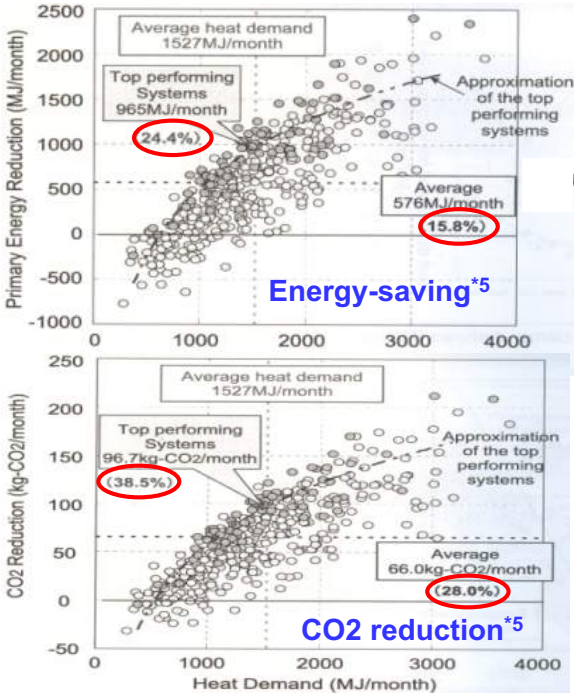


Global Backup Power/Forklift Market Projection[*4]



Global Trend & Status (cont'd)

- **Markets of stationary products growing, due to economic, energy-saving and emission mitigation benefits**
  - Residential CHP market expected to grow via PV market growth model
  - Backup power and forklift niche markets worldwide
- **No company with global presence**



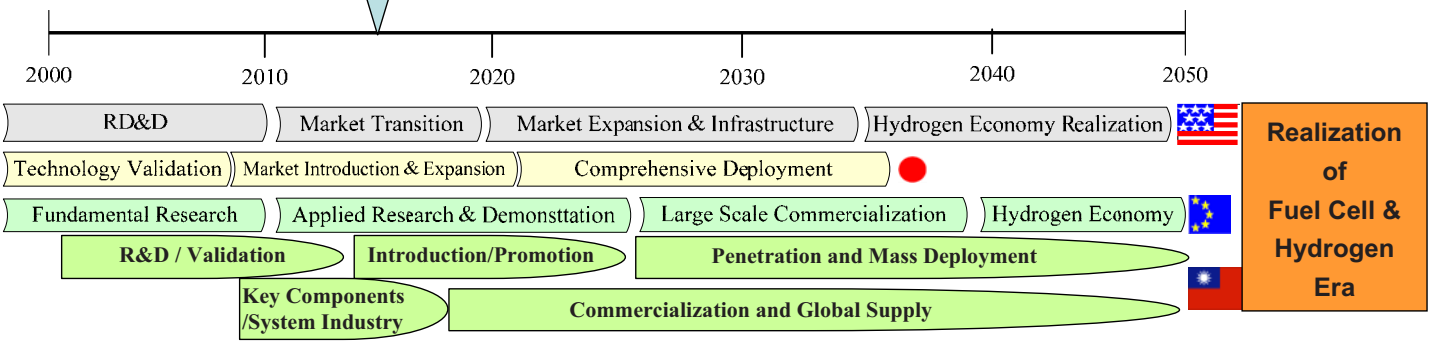
	3-Year Battery Replacement			5-Year Battery Replacement							
	Battery-Gen.*	PEMFC˜ without Tax Incentive	PEMFC with Incentive	Battery-Gen.	PEMFC without Tax Incentive	PEMFC with Tax Incentive	Gen. New Installation	Gen. Repl. Existing Installation	Battery-only	PEMFC without Tax Incentive	PEMFC with Tax Incentive
8-hour Runtime									19,037	14,023	12,136
52-hour Runtime	69,860	63,521	58,804	61,082	61,326	56,609					
72-hour Runtime				47,318	33,901	32,014	28,283	24,886			
176-hour Runtime	93,129	102,403	97,686	75,575	100,209	95,491	Ref. 4				

*Gen. is generator, ˜PEMFC is PEM fuel cell

Taiwan's Strategic Targets and Roadmap

- Cost of CHP system US$1500/kW @ 20,000 units/yr
- Among the leaders in low humidity (MT) MEA and photo-electrochemical hydrogen production technology

2015



Status & Trend in Taiwan

A Fast-Growing and Competitive Local Industry Centered around Distributed, Stationary Applications

- An existing & maturing local supply chain of SMEs
- Reputable mass production expertise and network for small industrial and consumer goods

Hydrogen

H2 Production
- CPC
- Air Products
- BOCLH
- Air Liquide

H2 Canister
- H Bank
- APFCT
- Hau-Yang

NG Supply
- CPC

Reformer
- TSTI
- Green Hydrotec
- Polaray
- Sentec

Methanol
- Merck
- Lee Chang Yung

Electrolyser
- EPOCH
- General-Optics

Methanol Cartridge
- Asia Vital

DuPont — **Fuel Cell**

Catalyst
- Enerage

Membrane

Electrode (Zinc-air)
- eVionyx

GDL
- CeTech
- Ample New

Bi-polar
- UIC
- En-liang
- Yonyu
- DHCO

MEA
- Optodisc
- General-Optics
- Nanya PCB
- Enerage

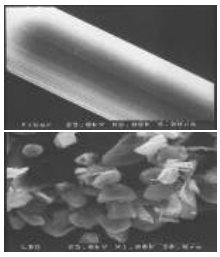
BOP
- KAORI
- TSTL
- Delta Elec.
- Phoenix
- Motech

Stack
- APFCT
- TSTI
- UIC
- Delta Elec.
- Nanya PCB
- Boyam
- Taigene
- Toplus
- CHEM

Systems
- Syspotek
- TSTI
- EnerMaster
- Delta Elec.
- Toplus
- CHEM
- Celxpert
- Simplo
- Coretronic
- APFCT
- Jemmytex
- Boyam
- Taipower

Note：Excluding research institutes and universities

Composite Bi-polar Plate Volume Production



Highly flexible bipolar plate

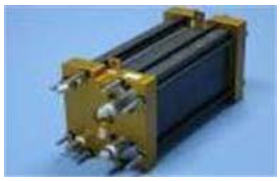
- Composite bi-polar plate by injection molding, complying DOE requirements
- Unelectra Intl. Corp. to be the first specialized FC component manufacturer in Taiwan

Property	DOE	S1 Co.	S2 Co.	ITRI
Tensile strength @ 25°C	3000 psi	3120 psi	2590 psi	3400 psi
Flexural strength @ 25°C	4000 psi	6010 psi	4870 psi	6200 psi
Electrical conductivity (XY Plane)	100 S/cm	163 S/cm	117 S/cm	145 S/cm 0.0068Ω-cm
Corrosion	1.6×10^{-5} A/cm²	5.1×10^{-7} A/cm²	2.7×10^{-6} A/cm²	1.9×10^{-7} A/cm²

(Exhibited in 2007 Hannover Messe and 2008 Hamburg Exhibition)

Stack Technology Evolution

- Indirect visualization
- 1- and 2-D flow simulation
- FEA structural analysis



1 kW

3 kW

5 kW

> 0.4W/cm²@ 0.65V

1.5 kW

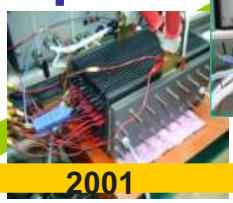
0.31W/cm²

volume reduction by 27.4%

300W

0.15W/cm²

3 kW



0.15W/cm²

Stack Assembly

1 kW

300W

2001 2002 2003 2004 2005 2006 2007

NG/LPG Reformer Development

ATR Reformer

•H_2 Conc. 40%~45%
•Op. Temp. 400~600°C

H_2-NG dual fuel burner

Anti-flashback valve

Design & Optimization

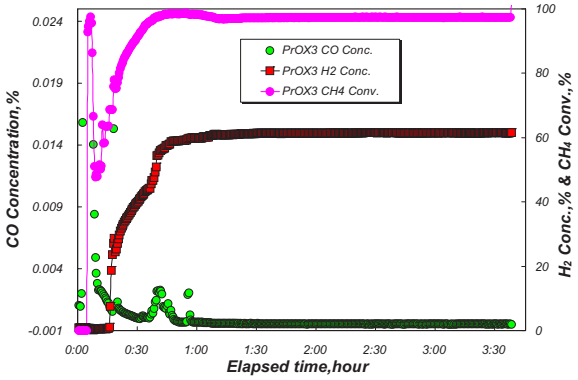
SMR Reformer (higher eff.)

•H_2 Conc. 60~70% (stable at 60%)
•Op. Temp. 700~1000°C

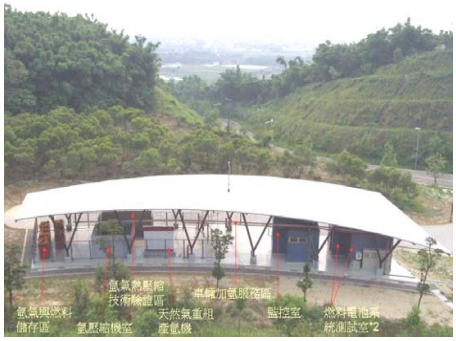
- Novel catalyst formulas
- Overall thermal efficiency ≧75%
- Less than 10ppm CO at stable operation
- Turn-down ratio better than 1/3

Challenges:

➢Durability of material and manufacture
➢Control of CO concentration, with dynamic loading



PEMFC & H_2 System Demonstration & Validation



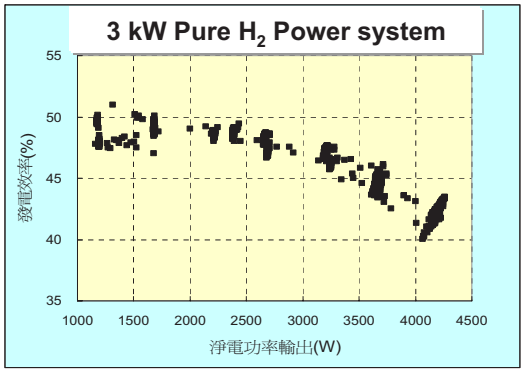
ITRI's Hydrogen Station (2008)

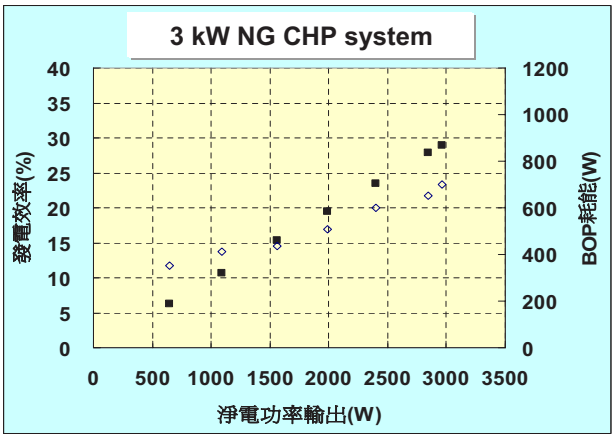
ITRI South (2008)

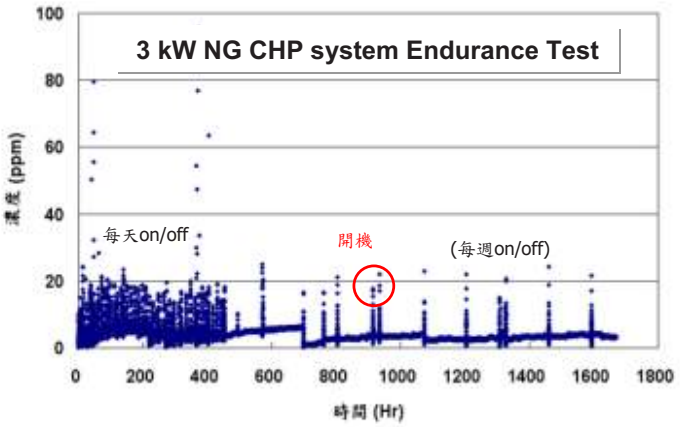
Hamburg Exhibition (2008)

TPRI (2006)

System Performance Testing







PEMFC CHP System Cost Analysis

- Initial material & machining cost share of the stack is ~40%, reformer plus its BOPs ~30% and the rest 30% for a lab. CHP system, based on ITRI experience.
- In terms of added-value, stacks and systems are at the top, followed by material and components.

Fuel Cell Products (US) Value Breakdown*1

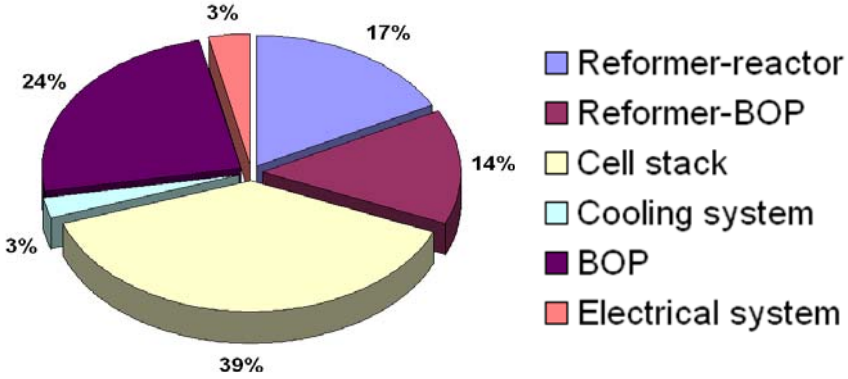
TABLE IV-2

COMMERCIAL FUEL CELL DEMAND
(million dollars)

Item	1997	2002	2007	2012	2017
Total Fuel Cell Spending	382	860	1825	3655	6550
% commercial	11.0	9.9	9.6	26.7	50.4
Commercial Fuel Cell Demand	42	85	175	975	3300
Stacks & Systems	23	46	92	495	1750
Fuels	4	8	16	180	750
Electronic Devices	4	8	19	100	300
Other Products & Services	11	23	48	200	500

Source: The Freedonia Group, Inc.

Initial PEMFC CHP Cost Structure from ITRI



- Based on real experience, BOPs & reformer are cost-down resistors for the initial market of limited volume

PEMFC Durability & Cost

- **High temp (above 100℃) configurations could be the best cost reduction option, considering the costs of water & heat management and fuel processing of the current system**
  - New proton conductor, catalyst and bi-polar plate needed, with sufficient durability
- **The next best option may be low-humidity and medium temp (80-90℃) configurations**
  - Chemically- and/or structurally-modified nafion-based membrane
  - Complimentary stack and GDL design to minimize non-uniformity effects
  - Mitigation of trace contaminants in the fuel and air streams and from BOP components
- **Technology research & development suitable for long term primary fuel feedstock**
  - Simplified fuel processing for bio-fuels, high-pressure electrolysis, and etc.

Collaboration Proposal

- **Joint Demonstration & Validation**
  CHP, backup power and other niche market systems in Taiwan & UK
- **PEMFC Products Development Collaboration**
  Niche market products for the EU market and worldwide (joint development, ODM/OEM, BOP supply chain)
- **Test Certification**
  Testing laboratory consulting services and mutual recognition (test once and accepted in UK/EU)
- **R&D Collaboration on PEMFC**
  Investigation into PEMFC durability issues and next-generation PEMFC technology under FP7
- **Key Technologies Transfer from UK**
- **Other Advanced Topics for Collaboration (H_2 production & storage)**

Acknowledgement

The support of the Petroleum Funds under the auspices of the Bureau of Energy, Ministry of Economic Affairs

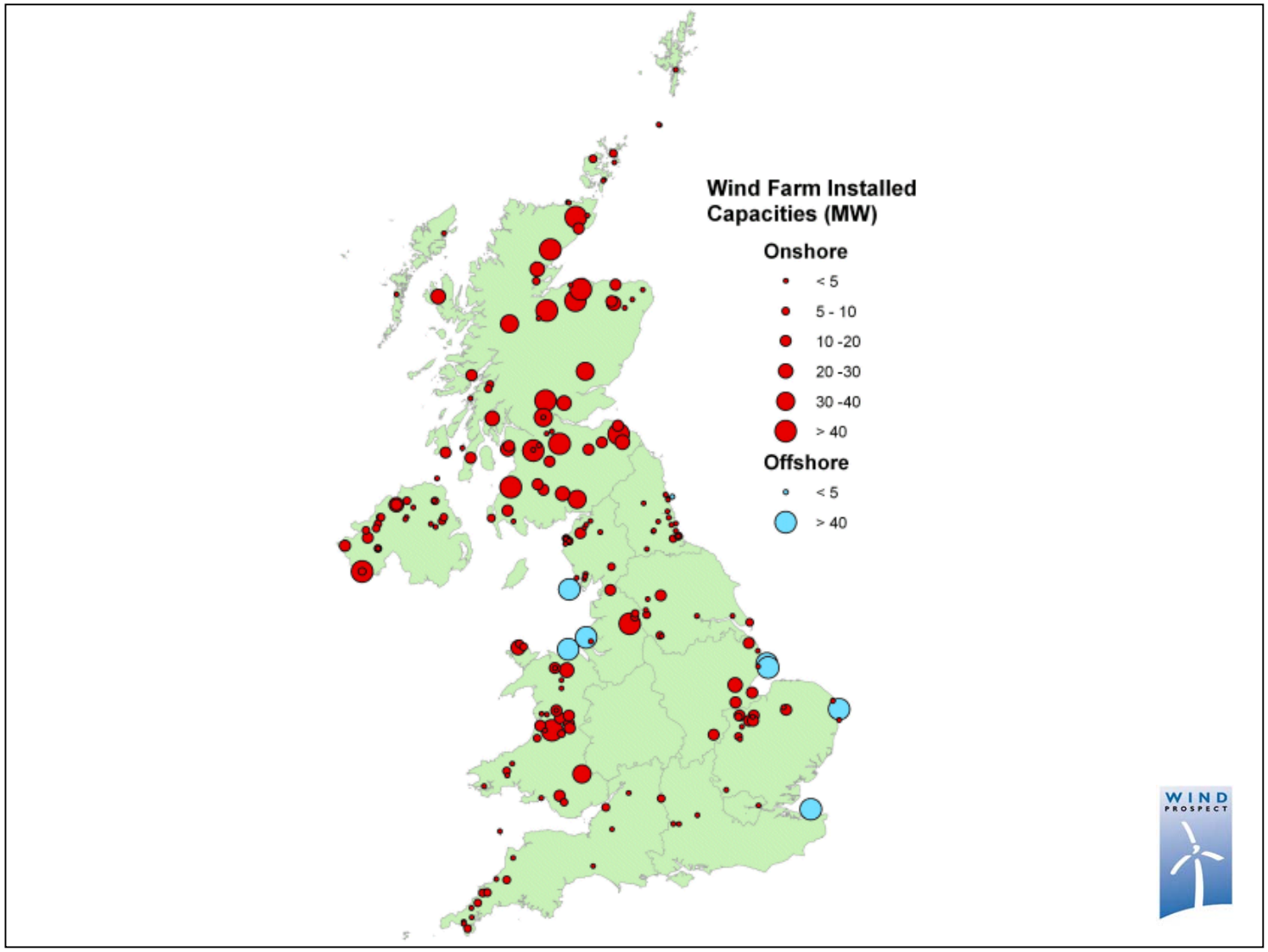
Reference

1. *Industry Study 2328—Fuel Cells*, Freedonia Group, April 2008
2. *Small Stationary Survey*, Fuel Cell Today, March 2009
3. *Ballard Power Systems*, A. Wong, Ballard Power Systems Inc., April 2009
4. *Identification and Characterization of Near-term Direct Hydrogen Proton Exchange Membrane Fuel Cell Markets*, K. Mahadevan, K. Judd, H. Stone, J. Zewatsky, A. Thomas, H. Mahy and D. Paul, Battelle Memorial Institute, April 2007
5. *Residential Fuel Cell Extensive Demonstration Project*, M. Okuda, New Energy Foundation, Feb. 2009

UK Wind Energy

The Fourth Taiwan-UK Renewable Energy Round Table Meeting

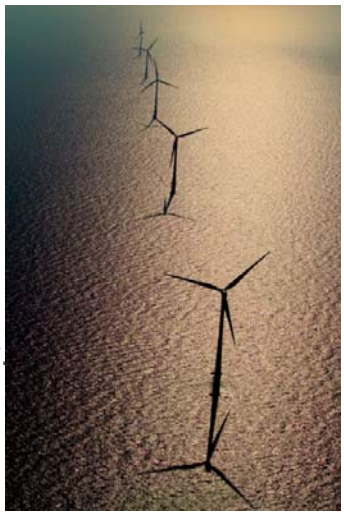
Wind Prospect Group
October 2009



UK Onshore Wind

- **Best wind resource in Europe.**
- **Joint 5th in the world wind energy attractiveness index.**
  - 3,233MW (240 projects) operational; first one in 1991.
  - 812MW (29 projects) currently under construction.
  - 3,279MW (158 projects) have received consent.
  - 7,386MW (264 projects) in development.
  - Target of at least 14GW by 2020.

UK Offshore Wind



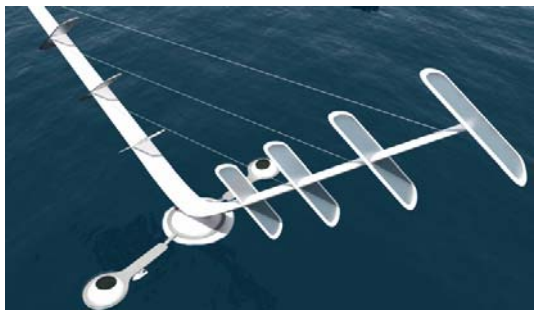
- **World leader in offshore wind**
  - 598 MW (8 projects) operational ~ 40% of total installed capacity.
  - 1,246MW (6 projects) currently under construction.
  - 3,613MW (9 projects) have received consent.
  - 2,639MW (5 projects) in advanced development.
  - Target of a further 25GW by 2020.

Policies and Programmes

- **Best incentives for offshore wind globally.**
- **Licensing rounds:**
  - Round 1 – 2001, 1GW
  - Round 2 – 2003, 7.2GW
  - Round 3 – 2009, 25GW
- **Strategic Environmental Assessment (SEA) to consider the environmental implications of leasing up to 33GW of offshore wind.**
- **New licensing regime for offshore electricity transmission to deliver cheaper and more timely connections.**
- **Working towards a streamlined, single consents regime for large projects.**

Investment in Technology

- **Energy Technologies Institute's Offshore Wind programme - £40m for design and demonstration of novel offshore wind systems:**
  - Deepwater - To design a 5MW floating offshore wind turbine for deepwater deployment.
  - Nova - Prove the feasibility of a Novel Offshore Vertical Axis turbine.
  - Helm Wind - Concept design and feasibility study of an offshore wind farm.



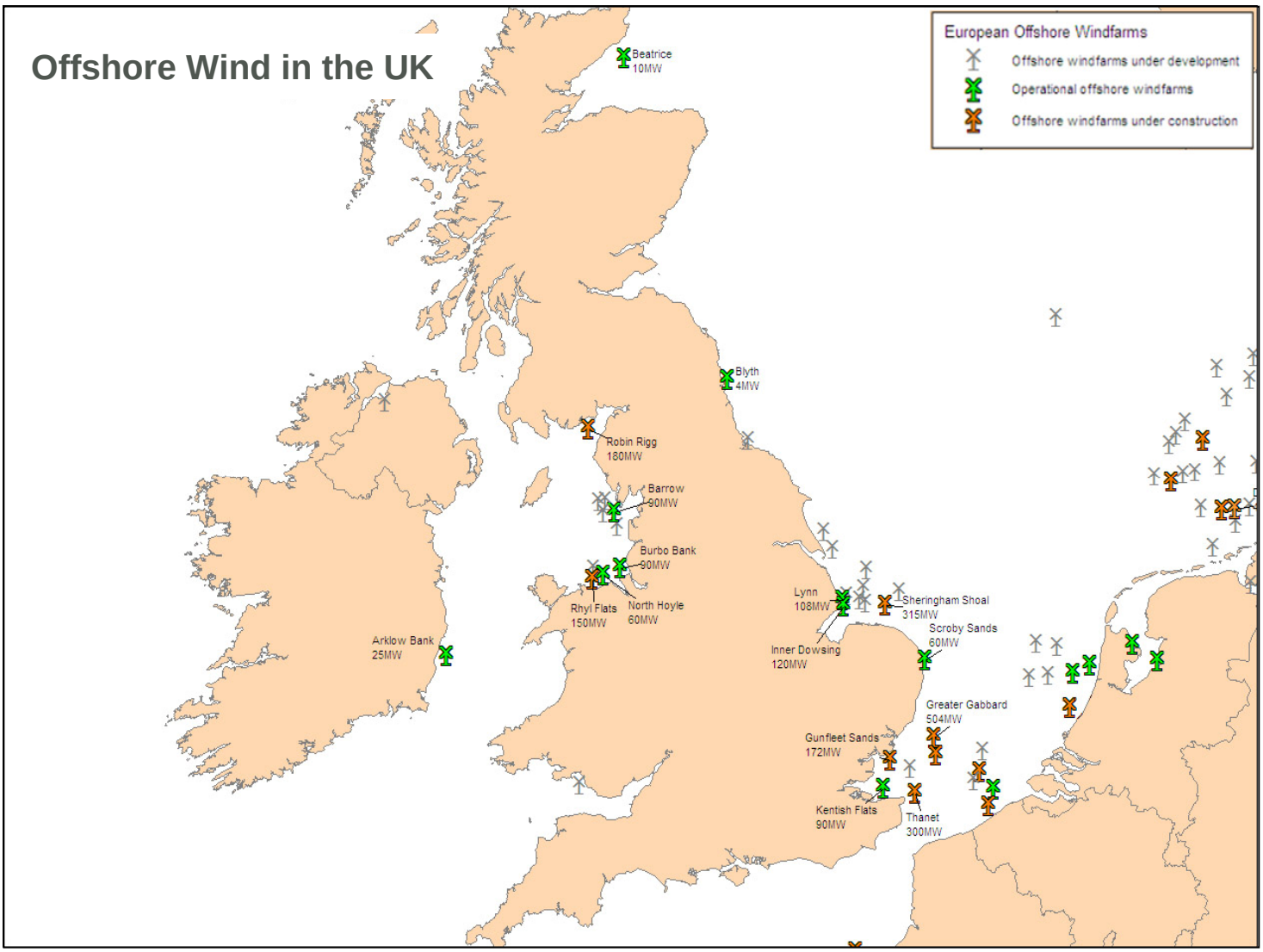
Investment in Technology

- **The Carbon Trust Offshore Wind Accelerator - £30m over next 5 years to cut the overall cost of offshore wind energy by 10%.**
- **Environmental Transformation Fund - capital grants for the demonstration of new offshore wind technologies.**
- **Test facilities – Narec:**
  - Independent centre for the development, testing and commercialisation of next generation technologies for the global wind energy industry.
  - Turbine and blade testing (dual axis).
  - Developing the world's largest offshore wind drive train test facility rated at 15MW.
- **Demonstrator projects:**
  - Beatrice – 2006, 2x 5MW
  - Blyth – 2000, 2x 2MW

Supply Chain

- **Decades of offshore oil & gas experience.**
- **Rapidly growing offshore wind specific supply chain:**
  - MPI – ‘Resolution’, the world's first purpose-built offshore turbine installation vessel. ‘Discovery’ and ‘Adventure’ under construction.
  - JDR Cables – new quayside manufacturing facility.
  - Bifab, Converteam etc.
  - Clipper - Established a ‘Centre of Excellence for Offshore Wind’ in Blyth, to develop the world's largest (10MW) offshore wind turbine.
  - Several wind turbine manufacturers looking at the UK for their next generation manufacturing facilities.

Offshore Wind in the UK



Thank you!

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Informing the fuel cell industry

The state of the global fuel cell industry and UK expertise

Dr. Jonathan Butler

Senior Market Analyst - Asia

Fuel Cell Today

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Fuel Cell Today – an Independent Resource

FCT Consulting

Three main types of analysis undertaken:

1. Can we use a fuel cell to power product 'X'?
2. We want to use fuel cells but what are our risks?
3. What are the future markets going to look like?

Website

www.fuelcelltoday.com :

1. 15+ free reports - analysis on developments in the industry over the past year
2. Reports on potential future developments in the industry (application and region)
3. News, directory etc. etc.

Fuel Cell Today Annual Review

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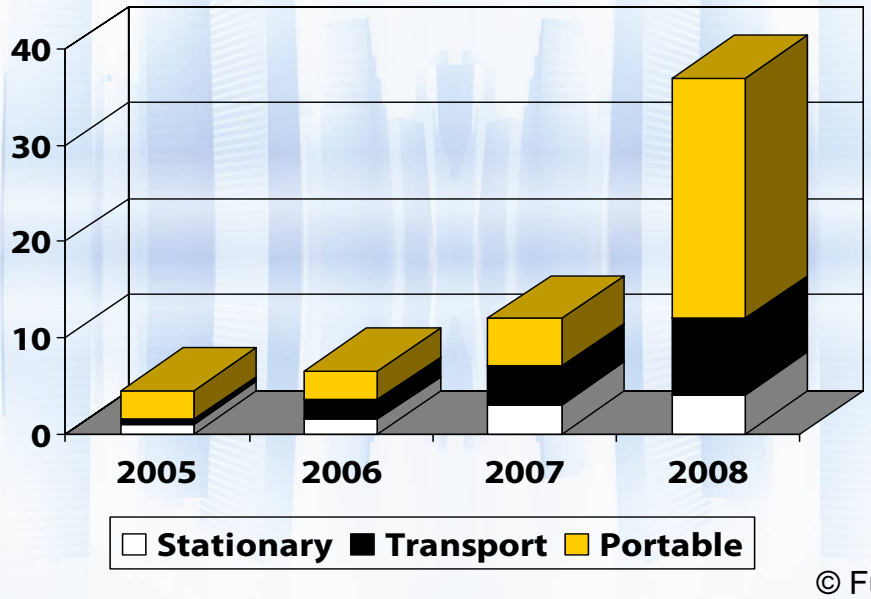
2005 – 2008 Units Shipped ('000s)



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State of the global industry (2009)

- 2008 shipments of fuel cells increased to 18,000 with a growth rate of over 50% from 2007
- A conservative estimate of current manufacturing capacity is 170 MW (up from just over 90 MW in 2007)
- In 2008 a number of new products became commercially available
- Globally, new policy and legislation increased the market pull for the technology
- The issue of codes and standards is being increasingly addressed







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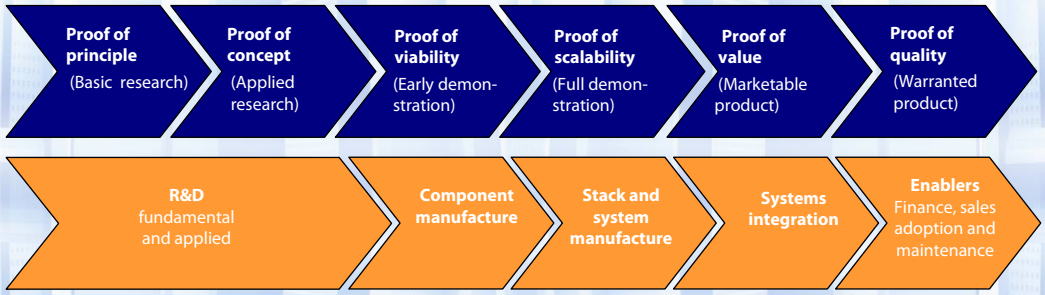
UK Fuel Cell and Hydrogen Expertise

• The UK has genuine pockets of industrial and commercial leadership throughout the supply chain:



• The UK has a thriving R&D sector with industrial links; a range of SME and larger corporate players in component, stack and system manufacturing; and key early adopters and 'enablers' such as financiers and market-technical consultants

CARBON TRUST

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UK policy landscape

• EU Hydrogen and Fuel Cell Joint Technology Initiative (H2FC JTI)

• Microgeneration support strategy

• King Review of Low Carbon Cars

• EUR 1 billion RD&D funding available over next decade

• Possibility of support for fuel cell mCHP

• Fuel cell vehicles seen as a longer term (20-30 yr) prospect to meet CO_2 targets

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Carbon Trust

Key focus: carbon saving potential

Breadth of low-carbon innovation activities, from R&D to demonstration, VC investment and full commercialisation

Seen as key partner by IP-sensitive innovators, especially universities, spin-outs and SMEs

Track record of delivery for ~5 years

Track record of links from innovation activities to policy making

Independent from Government and industry

TSB

Key focus: economic benefit for UK

Wider coverage than low-carbon/energy and potential to leverage cross-cutting disciplines

Established reputation with business sector

Strong focus on networking (KTNs) and skills transfer (KTPs)

Role in encouraging increased R&D spend in private sector

Independent from Government and industry

ETI

Key focus: route to market

Significant scale of funding available

Potential to fund projects at 100% due to combined public/private funding

Industry backed with direct route to market via industrial members

Access to management and engineering capabilities within industrial members

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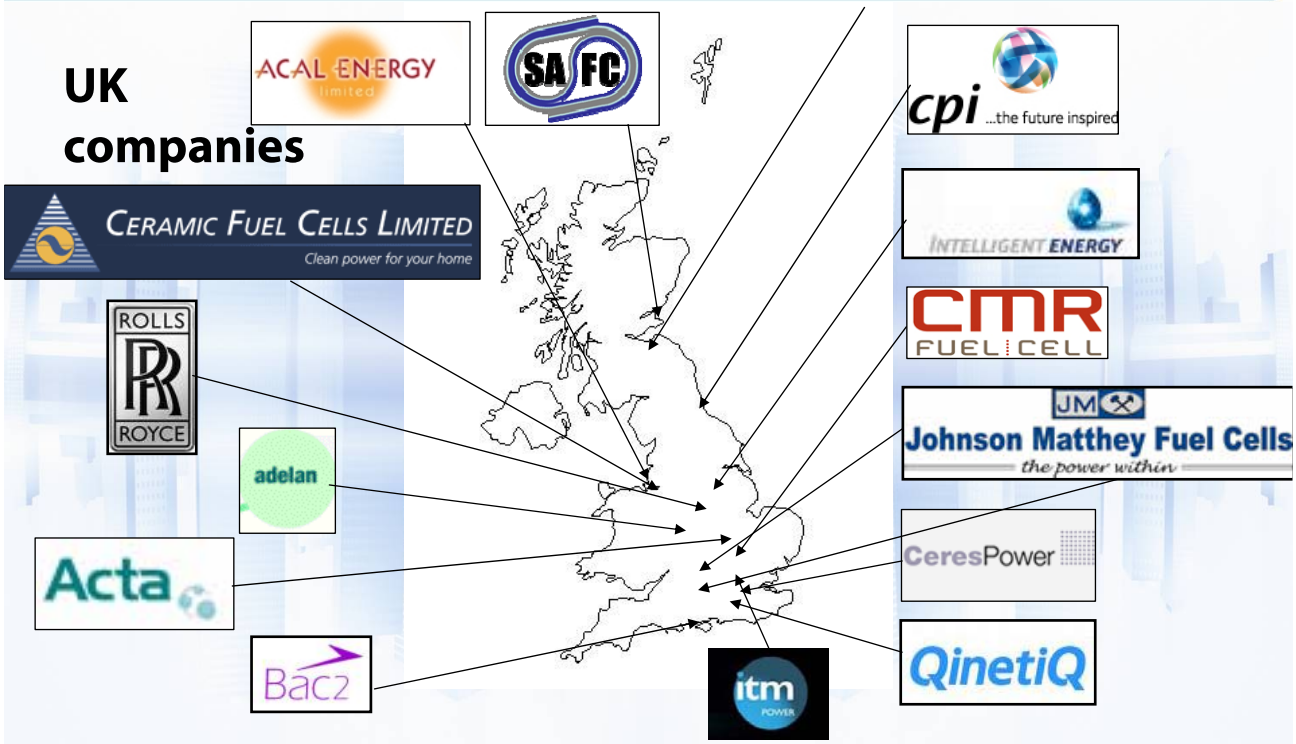
UK companies



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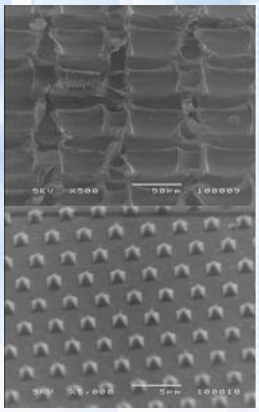
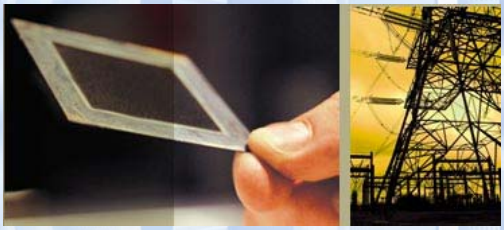
Imperial College London

Imperial College, London

• **PEM Research:** Optimisation of catalyst layer in fuel cells through explicit design



• **SOFC Research:** cathode, anode and electrolyte development. Spin-out: AIM-listed Ceres Power mCHP developer



CeresPower limited

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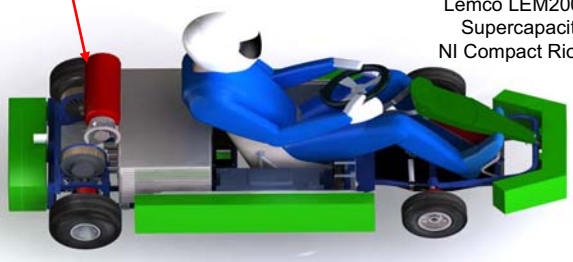
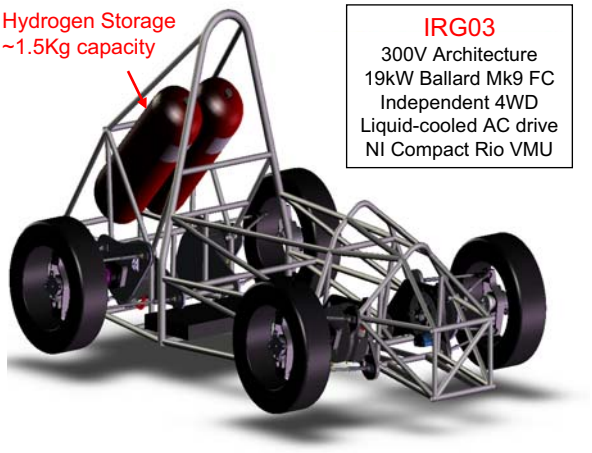
IRG01
48V Architecture
1.2kW PEM Fuel Cell
Lemco LEM200 (2x)
48V x 800A Battery

Hydrogen Storage
5L @ 200bar



IRG02
48V Architecture
8kW Hydrogenics FC
Lemco LEM200 (2x)
Supercapacitors
NI Compact Rio VMU

Hydrogen Storage
~1.5Kg capacity



IRG03
300V Architecture
19kW Ballard Mk9 FC
Independent 4WD
Liquid-cooled AC drive
NI Compact Rio VMU

FZ FORMULAZERO

Institution of Mechanical Engineers
Formula Student

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Loughborough University

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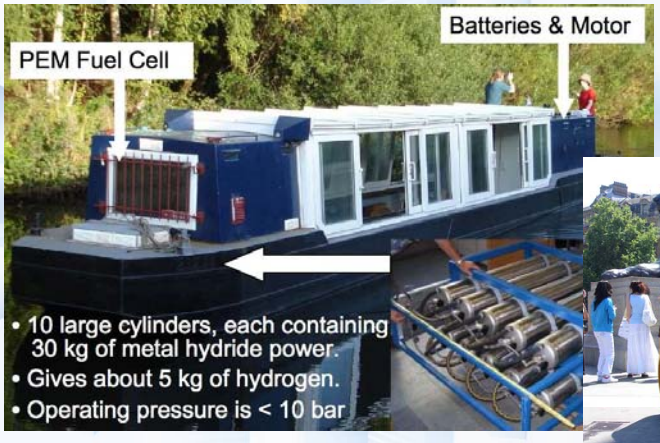
University of Birmingham



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Component manufacturers

NAME	ORIGIN/TECHNOLOGY/ BUSINESS AREA
Bac2 Conductive Composites	Start-up. Bipolar plates using novel materials science.
CMR Fuel Cells	Start-up. DMFC component and stack manufacturer.
Dek Printing Machines	Corporate. Substrates and membrane printing technology.
Johnson Matthey Fuel Cells	Corporate. PEM and PAFC component manufacture.
Oxford Catalysts	University spin-out. Hydrogen-on-demand
Ilika	University spin-out. Materials research.

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Stack/system manufacturers

NAME	ORIGIN/TECHNOLOGY/ BUSINESS AREA
Acal Energy	Spin-out. Platinum-free electrode technology.
Adelan	Spin-out. Small-scale tubular SOFC
Ceramic Fuel Cells Limited (CFCL)	Start-up. Residential SOFC CHP developer, tie-in with utilities.
Ceres Power	Spin-out. Residential SOFC CHP developer, tie-in with utilities.
CMR Fuel Cells	Start-up. DMFC component and stack manufacturer.
Intelligent Energy	Spin-out. Stack; system; fuel processing. Product Stack: 1-75kW PEM unit.
Rolls Royce Fuel Cell Systems	Corporate. SOFC manufacturer of 'power plant' (100s kW – MW) scale.
St. Andrew's Fuel Cells.	Spin-out. Tubular SOFC technology.
Voller Energy	Start-up. Portable PEM systems integrator.

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System integrators and consultants

NAME	ORIGIN/TECHNOLOGY/ BUSINESS AREA
Element Energy	Engineering consultancy with emphasis on fuel cells
Logan Energy	Systems integrator with experience of installing SOFC and PEM units in buildings

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Adopters/enablers

NAME	TECHNOLOGY/ BUSINESS AREA
CoreTech Ventures	Small VC and advisory company, highly focused on fuel cell techs
Conduit Ventures	Small VC company, focused on wider cleantech industry but with strong emphasis on fuel cells
Black Country Housing Association	Innovative Housing Association with experience of installing and running fuel cells in residential applications and at the University of Birmingham.
LHP/TfL	Transport for London's hydrogen vehicle project will see 60 H2 fuel cell and ICE vehicles on London's roads by 2010.
Pure/Unst	Hydrogen/Fuel cell/Renewable research centre in the Shetlands. Innovative hydrogen community project.
UPS Systems	Fuel cell in UPS Systems office (UPS the fuel cell company, not the delivery company!).
Woking Borough Council	Installed 200 kWe fuel cell on private wires, groundbreaking project for the UK.

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Senior Market Analyst, Asia

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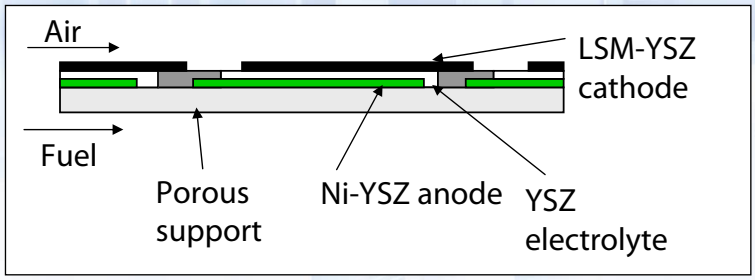

- 900deg
- 10 bar
- 55% efficiency

www.rolls-royce.com/energy/tech/fuelcells.jsp

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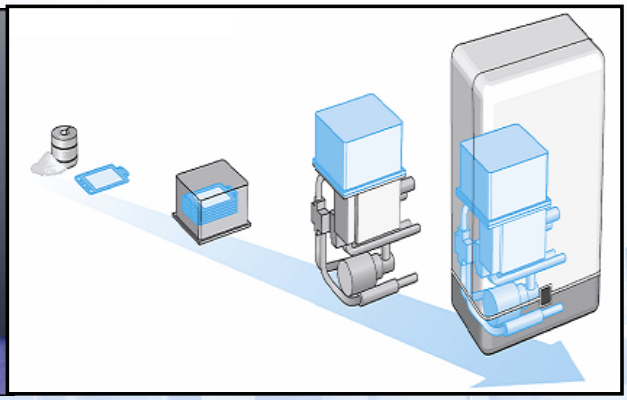

- 1 kW fuel cell stack
- 600deg CGO
- Metal-supported

- Market target:
  - Wall-mounted CHP unit replacing boiler

www.cerespower.com

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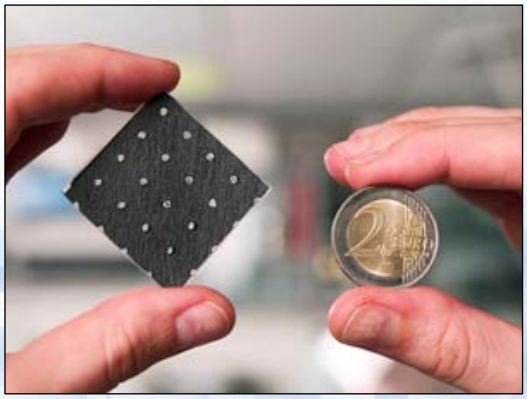

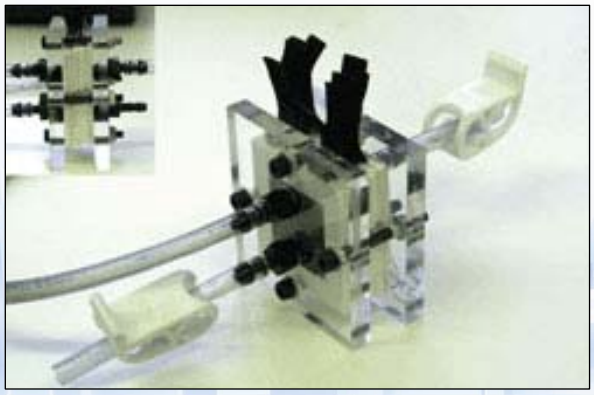

- MicroFC (tens of W)
- Selective catalysts
- Working with ODM on system manufacturing

- Market target:
  - Portable electronics
  - Remote monitoring

www.cmrfuelcells.com

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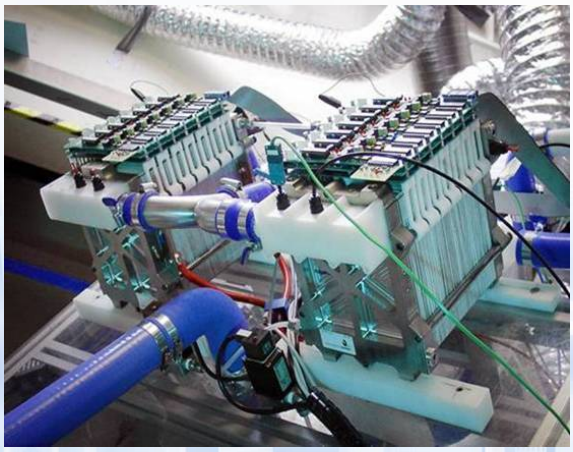
Boeing plane



Motorbike - ENV

- High power density metal plate technology
- Automotive and Stationary

www.intelligent-energy.com

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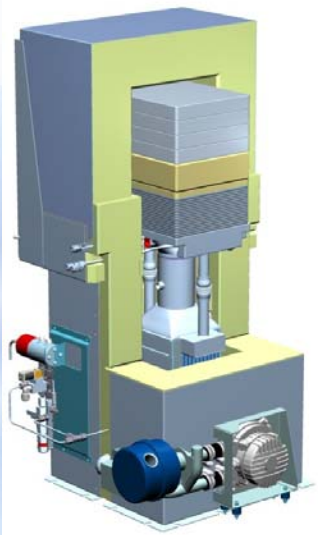

- 800deg YSZ
- Multinational company
- Commercial product agreements

www.cfcl.com.au

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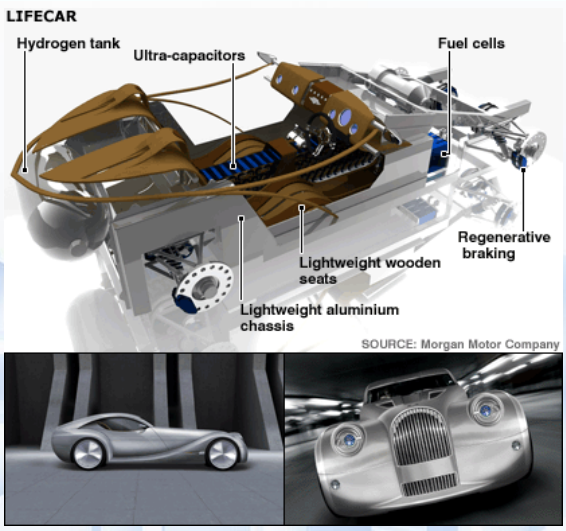

- 10kW PEM
- Morgan vehicle
- Novel structures

www.qinetiq.com